BULLETIN OF THE IMPERIAL INSTITUTE

A QUARTERLY RECORD OF PROGRESS IN TROPICAL AGRICULTURE AND INDUSTRIES AND THE COMMERCIAL UTILISATION OF THE NATURAL RESOURCES OF THE DOMINIONS, COLONIES AND INDIA

EDITED BY THE DIRECTOR AND PREPARED BY THE SCIENTIFIC AND TECHNICAL STAFF OF THE IMPERIAL INSTITUTE AND BY OTHER CONTRIBUTORS

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THE IMPERIAL INSTITUTE

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UNITED KINGDOM, THE COLONIES AND INDIA

THE Imperial Institute was erected at South Kensington as the National Memorial of the Jubilee of Queen Victoria, by whom it was opened in May 1893.

The principal object of the Institute is to promote the utilisation of the commercial and industrial resources of the Empire: (i) by arranging comprehensive exhibitions of natural products, especially of the Dominions, Colonies and India; and (ii) by providing for their investigation, and for the collection and dissemination of scientific, technical and commercial information relating to raw materials.

Until the end of 1902 the Imperial Institute was managed by a Governing Body, of which H.R.H. the Prince of Wales (afterwards King Edward VII.) was President, and an Executive Council, including representatives of the Indian Empire and of all the British Colonies and Dependencies. In 1900 the building became the property of H.M. Government, by whom the western portion and galleries were leased to the Governing Body of the Imperial Institute, the greater part of the eastern and central portions being assigned, subject to rights of usage, for occupation by the University of London. In July 1902 an Act of Parliament was passed transferring the management of the Imperial Institute to the Board of Trade, assisted by an Advisory Committee including representatives of the Dominions, Colonies and India, as well as of the Colonial and India Offices, the Board of Agriculture and the Board of Trade.

Under a subsequent arrangement between the Departments concerned, the Colonial Office became chiefly concerned with the management of the Imperial Institute.

In April 1916 the Imperial Institute (Management) Act was passed transferring the property and management of the Imperial Institute to the Secretary of State for the Colonies. The Act provides for the appointment of an Executive Council consisting of twenty-five members, nominated by the Board of Trade, the Secretary of State for India (two each), the President of the Board of Agriculture and Fisheries, the Government of India, the Governments of the several Dominions (one each), and the Secretary of State for the Colonies (fourteen). A list of the present members of the Council is given on pp. xi and xii and also of the various Committees which have been appointed (pp. xii–xvii).

The staff of the Imperial Institute includes officers with special qualifications in the sciences of chemistry, botany, geology and mineralogy, and in certain branches of technology, in their relation to commerce and to the industrial utilisation of raw materials.

The following are the principal departments of the Institute:

Public Exhibition Galleries.—The collections of raw materials, etc., illustrative of the industrial and commercial resources of the Dominions, Colonies and India, are arranged, together with other exhibits, on a geographical system in the public galleries of the Imperial Institute. The galleries are open free to the public, daily (except on Sundays, Good Friday and Christmas Day), from 10 a.m. to 5 p.m. in summer, and from 10 a.m. to 4 p.m. in winter.

The following British Dominions, Colonies and Dependencies are represented by Collections, which are in charge of Technical Superintendents:

Canada, Newfoundland; Jamaica, Turks and Caicos Islands, British Honduras, British Guiana, Bahamas, Trinidad and Tobago, Barbados, Windward Islands, Leeward Islands, Bermuda; Falkland Islands; New South

Wales, Victoria, Queensland, Tasmania, South Australia, Western Australia, Papua, Northern Territory, New Zealand; Fiji, Western Pacific Islands; Union of South Africa, Rhodesia, Nyasaland, St. Helena; Gambia, Sierra Leone, Gold Coast, Nigeria; East Africa Protectorate, Zanzibar and Pemba; Uganda; Somaliland; Sudan; Malta; Cyprus; Ceylon; Hong Kong; Mauritius; Seychelles; Straits Settlements, the Federated Malay States; and the Indian Empire.

An Egyptian collection is in course of formation.

A reference collection of standard raw materials of commerce is shown temporarily in the Ceylon Pavilion.

Arrangements are made to conduct parties from schools and educational institutions through the Collections and to explain the exhibits. Short lectures on the countries of the Empire and their resources are given periodically in connection with the Collections.

A Central Stand for the distribution of publications and an Enquiry Office have been opened in the main gallery to provide for the supply of general information and the distribution of literature. Handbooks, pamphlets, circulars, etc., containing information relating to the commerce, agriculture, mining and other industries of the Dominions and Colonies, and also in regard to emigration, are available for free distribution or for sale. Lists of the publications available for distribution or sale are provided, and the principal Colonial and Indian newspapers may be seen on application.

Owing to the occupation by the War Office of a part of the Galleries having only recently terminated, some of the facilities referred to above are still restricted, but all will again be available at an early date.

Scientific and Technical Research Department.—The technical laboratories and workrooms of this Department were established in order to provide for the investigation of new or little-known raw materials from the Dominions, Colonies and India, and of known products from new sources, with a view to their utilisation in commerce. Materials investigated by the Department are in pro-

mising cases submitted to further technical trials by manufacturers and other experts, and finally are commercially valued.

The work of this Department is chiefly initiated by the Home, Dominion and Colonial Governments and the Government of India. Arrangements have also been made by the Department of Overseas Trade whereby British representatives abroad may transmit to the Institute, for investigation, such raw materials of the countries to which they are appointed as are likely to be of interest to British manufacturers and merchants.

Special analyses and investigations are undertaken for firms or private persons in any part of the Empire on payment of appropriate charges. Application for such investigations should be made, in writing, to the Director.

A Reference Sample Room is maintained in this Department, in which are arranged samples of the principal raw materials which have been investigated and valued commercially during recent years, and as to which full information is available.

The Department works in co-operation with the Agricultural, Mines and other Technical Departments in the Dominions, Colonies and India, whose operations it supplements by undertaking investigations and enquiries of a special scientific or technical character connected with agricultural or mineral development, as well as enquiries relating to the composition and commercial valuation of products (animal, vegetable or mineral) which can be more efficiently conducted at home in consultation with manufacturers and merchants, with a view to the local utilisation of these products or to their export.

A large number of reports on these subjects have been made to the Governments of the Dominions, the Colonies and India, a first instalment of which was printed in a volume of *Technical Reports and Scientific Papers*, published in 1903. A series of Selected Reports is now being issued in the Miscellaneous Series of Colonial Reports which are presented to Parliament (see p. viii).

Mineral Surveys are conducted in countries of which

the mineral resources are little known. All minerals found that are likely to be of commercial importance are forwarded to the Imperial Institute, where they are examined and their composition and commercial value ascertained. Reports on the results of mineral exploration in Ceylon, Northern Nigeria, Southern Nigeria, and Nyasaland have been printed in the Miscellaneous Series of Colonial Reports and presented to Parliament. The work of the Imperial Institute on minerals is carried on with the advice of the Committee on Mineral Resources (see p. xvi).

Technical Information Bureau.—This is a branch of the Scientific and Technical Research Department which has been formed to deal with the large and increasing number of enquiries received by the Imperial Institute from manufacturers, merchants and others, throughout the Empire. The Bureau has devoted special attention to questions relating to the raw materials required for the industries of the Empire. It has supplied technical information to enquirers, and has issued circulars and pamphlets dealing with various problems in connection with the supply and disposal of raw materials of all kinds.

Indian Trade Enquiry.—The Secretary of State for India has requested the Committee for India of the Institute to enquire into and report on the possibilities of extending the industrial and commercial utilisation of Indian raw materials in this country and elsewhere in the Empire. Special Committees have been appointed to deal with the more important groups of Indian materials, to consider the results of investigations and enquiries already conducted at the Imperial Institute, and to obtain the views of leading merchants, manufacturers, and other users of the raw materials of India. A number of reports have already been furnished to the India Office, and these are now in course of publication as a series of volumes by Mr. John Murray. A list of the members of these Special Committees is given on pp. xiv and xv.

Tropical African Services Course.—Courses of instruction in certain specified subjects are given at the Imperial Institute to candidates selected by the Colonial Office for administrative appointments in East and West Africa. Instruction in these Courses in the subject of Tropical Economic Products is given by a member of the Staff of the Imperial Institute.

Library, Reading-Rooms and Map-Room.—The library and reading-rooms of the Imperial Institute contain a large collection of works of reference, and are regularly supplied with the more important official publications, and with many of the principal newspapers and periodicals of the United Kingdom, the Dominions, the Colonies, India and Foreign Countries. Special attention is given to publications relating to tropical agriculture and forestry, mineral resources, and the production and utilisation of raw materials.

The map-room, which adjoins the reading-rooms, is provided with a large collection of recent maps of the Dominions, the Colonies and India, which can be seen on application.

Conference Rooms.—These rooms, specially decorated and furnished, are reserved on the principal floor for use by representatives of the Dominions and Colonies and for meetings and receptions.

The Cowasjee Jehangier Hall.—The Bhownaggree corridor and rooms in connection with the Cowasjee Jehangier Hall are in the occupation of the Indian Section of the Imperial Institute, whilst the Hall is available for lectures, meetings, etc.

Publications

Bulletin of the Imperial Institute.—The BULLETIN is published quarterly by Mr. John Murray, 50A, Albemarle

Street, London, price 3*s.* 6*d.* (annual subscription 14*s.*, postage extra), and may be purchased through any bookseller. It contains records of the principal investigations carried out at the Imperial Institute, and special articles chiefly relating to the industrial utilisation of raw materials and progress in tropical agriculture.

Handbooks to the Commercial Resources of the Tropics.—The Secretary of State for the Colonies has authorised the preparation of a series of handbooks dealing with the Commercial Resources of the Tropics, with special reference to West Africa. The handbooks are edited by the Director of the Imperial Institute and published by Mr. John Murray. The first four volumes are: *The Agricultural and Forest Products of British West Africa*, by Gerald C. Dudgeon, Consulting Agriculturist, Ministry of Agriculture, Egypt, and lately Inspector of Agriculture for British West Africa, price 6*s.* net; *Cocoa: Its Cultivation and Preparation*, by W. H. Johnson, F.L.S., Director of Agriculture in Southern Nigeria, price 6*s.* net; *Rubber: Its Sources, Cultivation and Preparation*, by Harold Brown, Technical Superintendent, Scientific and Technical Department, Imperial Institute, price 6*s.* net.; and *Cotton and other Vegetable Fibres: their Production and Utilisation*, by Ernest Goulding, D.Sc., F.I.C., Scientific and Technical Department, Imperial Institute, 2nd edition, price 7*s.* 6*d.* net.

Monographs on Industrial Resources.—The Imperial Institute has devoted special attention to the question of securing the utilisation in the United Kingdom of the large quantities of materials produced within the Empire which before the war were exported chiefly to foreign countries. It is intended to deal with this subject in a series of Monographs. In order to call attention to the subject of oil seeds, a monograph, entitled *Oil Seeds and Feeding Cakes*, has been issued. This book, which is published by Mr. John Murray, price 2*s.* 6*d.* net, deals with the production and utilisation of copra, palm kernels, ground nuts, sesame seed and mowra seed, and the oils and feeding cakes obtained from them.

The Mineral Resources Committee of the Imperial Institute have arranged for the publication of a series of monographs on mineral resources with special reference to those of the British Empire. The first of these monographs, dealing with Zinc Ores, may be obtained from the Imperial Institute, price 2*s.* post free. Those on Manganese Ores, Tin Ores and Tungsten Ores are now published by Mr. John Murray, price 3*s.* 6*d.* net, and also that on Coal, price 5*s.* net.

A Map and Diagrams of the Chief Metal Resources of the Empire, prepared at the Imperial Institute with the advice of the Imperial Institute Committee on Mineral Resources, is now issued. The chief British countries of occurrence and production of the principal minerals are shown on the map. The diagrams give the outputs of these countries for 1915 in relation to the production of other countries of the world. The metals dealt with are: gold, silver, platinum, copper, tin, lead, zinc, antimony, aluminium, bismuth, iron, manganese, chromium, nickel, tungsten, molybdenum, vanadium, and mercury.

The map and diagrams are mounted on linen and folded. The publication is obtainable from the Imperial Institute, price 5*s.* 6*d.* (post free).

Selected Reports from the Scientific and Technical Department.—These reports, which are issued in the Miscellaneous Series of Colonial Reports, contain a summary of the results of technical and commercial investigation of certain raw materials conducted in the Scientific and Technical Research Department of the Imperial Institute since 1903. Five of these Selected Reports have been published: Part I. "Fibres"; Part II. "Gums and Resins"; Part III. "Foodstuffs"; Part IV. "Rubber and Gutta Percha"; Part V. "Oilseeds, Oils, Fats and Waxes."

Organisations with Headquarters at the Institute

International Association for Tropical Agriculture, British Section.—The object of this Association, the Central Bureau of which is in Paris, is to promote the scientific

and practical study of all questions connected with tropical agriculture, including the development and utilisation of natural resources, and to arrange for International Congresses. The British Section has its headquarters at the Imperial Institute. Members of the British Section receive the Bulletin of the Imperial Institute and are permitted to use the library and reading-rooms of the Imperial Institute.

Overseas Nursing Association.—An office on the mezzanine floor has been allotted to this Association, the principal object of which is the selection of trained hospital and private nurses for service in the Crown Colonies and Dependencies.

African Society.—This Society has been temporarily provided with an office at the Imperial Institute, and meetings of the Society are held there.

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REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Dominion, Colonial and Indian Governments.

INVESTIGATIONS OF THE QUALITY OF PLANTATION RUBBER CONDUCTED UNDER THE CEYLON RUBBER RESEARCH SCHEME—III.

THE present report is the third of a series giving the results of mechanical and vulcanisation tests, and of the chemical examination of samples of rubber prepared in connection with the scheme of rubber research arranged by the Government of Ceylon in conjunction with some of the principal planting companies in the island, and with the Imperial Institute. The previous reports were published in this BULLETIN (1916, **14**, 495, and 1918, **16**, 409). The principal object of the work is to ascertain the methods of preparing plantation rubber which lead to the production of rubber of the quality required by the rubber manufacturer.

The investigations dealt with in the following pages relate to (1) the effect on the properties of scrap rubber of different methods of preparation and treatment, and the cause of the general inferiority of this rubber, (2) the effect of smoking on the mechanical properties of the vulcanised rubber, (3) the effect of evaporating latex in a vacuum drier, (4) the effect of different methods of drying, and (5) the effect of preparing rubber in various ways. The last-named trials were mostly carried out with the object of ascertaining whether rubber made under estate conditions would give similar results to small-scale specimens prepared

earlier (Series I and II); in addition three of the rubbers were prepared to determine the effect of adding acetic acid to the latex without stirring. The details given as to the preparation of the samples were supplied by Mr. L. E. Campbell, B.Sc., F.I.C., lately Rubber Research Chemist in Ceylon, under whose superintendence the samples were prepared. The vulcanisation and mechanical tests at the Imperial Institute were carried out by Mr. R. G. Pelly, F.I.C., and Mr. F. L. Elliott, and the chemical examination of the samples has also been conducted at the Imperial Institute, chiefly by Mr. B. W. Whitfeild, A.I.C. Details as to the methods of testing the rubbers are given in this BULLETIN (1916, **14**, 499).

(1) SCRAP RUBBERS

SERIES V

Sections VIII to XI were prepared on Gikiyanakande Estate from scrap rubber taken from ten-year-old trees. Except in the case of Section X, the scrap was bulked and mixed as much as possible for each set of experiments.

Section VIII. Treatment of Scrap Rubber

No particulars were furnished beyond the labels on the samples.

No. 305. Plain scrap.
No. 306. Crêped scrap.
No. 307. Scrap washed in Universal Washer and crêped.
No. 308. Scrap steamed and crêped.

Section IX. Treatment of Scrap Rubber

Date of experiment: July 21, 1915.

No. 309. Scrap allowed to dry by spreading on floor of a warm dry room. Direct sunlight was not allowed to fall on the rubber.
No. 310. Scrap steamed and then made into crêpe by passing through rollers.
No. 311. Scrap worked up in crêpe form by passing through washing rollers.

No. 312. Scrap washed in a Universal Washer and then crêped.

No. 313. Scrap steamed, made into crêpe, and smoked.

Section X. Collection of Scrap Rubber

In these experiments, certain trees were tapped on July 24. From one quarter of the trees the scrap was collected on the evening of the 24th ; from the second quarter on the 25th ; from the third quarter on the 27th ; and from the fourth quarter on July 30. During the period covered by this experiment, the weather was moderately fine and the scrap on the trees was subjected to the action of sunlight.

The collection of the scrap from the trees on the day of tapping was a difficult operation owing to the amount of moisture present in the rubber. After remaining on the tree for one day, the surface of the scrap is partially dry, and removal is then effected with but little difficulty.

Each sample of scrap was spread on the floor of a warm room out of direct sunlight.

No. 314. Scrap collected on day of tapping.
No. 315. Scrap collected on day after tapping.
No. 316. Scrap collected three days after tapping.
No. 317. Scrap collected six days after tapping.

Section XI. Treatment of Scrap Rubber

Date of collection : July 27, 1915.

The scrap from the field was bulked and mixed. It was then divided into five lots and treated as follows :

No. 318. Scrap spread on floor in dark.
No. 319. Scrap spread on floor in light room.
No. 320. Scrap spread on floor in sunlight.
No. 321. Scrap left in a heap in a dark room.
No. 322. Scrap left in a heap in sunlight.

Results of Examination

The vulcanising and mechanical properties of the rubbers were determined with the following results :

TABLE I

Results of Vulcanisation and Mechanical Tests

Series V, Sections VIII—XI

	Form of rubber.	Serial number.	Time of vulcanisation.	Tensile strength.	Elongation.	Permanent set.	Ash. Total.	Ash. Sand and silica.
			Minutes.	*lb. per sq. in.*	*Per cent.*	*Elongation per cent.*	*Per cent.*	*Per cent.*
Section VIII. Treatment of Scrap Rubber.								
Plain scrap	Scrap	305	100	1,530	808	5·6	2·17	1·03
Crêped scrap	Thin crêpe	306	120	1,920	835	4·0	0·82	0·26
Scrap washed in Universal Washer and crêped	do.	307	115	1,620	792	4·0	1·90	1·17
Scrap steamed and crêped	do.	308	135	1,300	771	Broke	1·33	0·65
Section IX. Treatment of Scrap Rubber.								
Scrap dried on floor of warm dry room, direct sunlight not allowed to fall on the rubber	Scrap	309	90	1,290	771	5·4	3·69	2·35
Scrap steamed and then crêped by passing through rollers	Thin crêpe	310	125	1,200	750	Broke	1·86	not determined
Scrap worked up into crêpe form by passing through washing rollers	do.	311	130	1,470	772	Broke	0·83	do.
Scrap washed in Universal Washer and then crêped	do.	312	105	1,910	853	3·0	0·71	0·22
Scrap steamed, made into crêpe and smoked	Thin crêpe, smoked	313	130	1,640	782	3·7	0·98	0·44
Section X. Collection of Scrap Rubber.								
Scrap collected on day of tapping	Scrap	314	100	1,930	842	3·1	0·79	0·30
Scrap collected day after tapping	do.	315	120	1,310	774	5·0	not determined	
Scrap collected three days after tapping	do.	316	100	1,600	808	4·2	1·22	0·53
Scrap collected six days after tapping	do.	317	100[1]	1,300	833	5·1	not determined	
Section XI. Treatment of Scrap Rubber.								
Scrap spread on floor in dark	do.	318	95	1,400	788	5·1	4·10	2·78
Scrap spread on floor in light room	do.	319	90	1,440	791	4·6	2·48	1·28
Scrap spread on floor in sunlight	do.	320	95	1,470	784	4·4	3·14	2·08
Scrap left in heap in dark room	do.	321	100	1,390	774	5·4	3·59	2·49
Scrap left in heap in sunlight	do.	322	90	1,250	759	6·3	5·89	4·64

[1] *Undercured.*

The washing losses for these scrap rubbers varied considerably in different experiments; the question is dealt with on page 6.

Remarks

Considerable difficulties were experienced in determining the vulcanising and mechanical properties of these scrap rubbers owing to the fact that test rings from the same slab of vulcanised rubber, or from different slabs of the same rubber vulcanised together, frequently gave widely varying results for tensile strength and elongation. In addition, scrap rubbers do not as a general rule appear to show the rapid drop in tensile strength and elongation when cured beyond a certain point, such as is evident in the case of latex rubber. These two features make it difficult to decide when a scrap rubber is cured to the degree adopted as the standard for purposes of comparison. In the present report all the samples have been cured to such a point that the slope of the stress-strain curve agrees as nearly as possible with the slope of the average curve given by latex rubbers at "standard cure." Determinations of the co-efficient of vulcanisation of certain of the samples of scrap rubber cured in this way indicated that there is in the case of scrap rubbers a definite relationship between the slope of curve and the co-efficient of vulcanisation such as exists in the case of latex rubbers, and that the times of cure required to produce a curve of definite slope can be taken as a basis for the comparison of the vulcanising properties of scrap rubbers.

Another problem which presents itself in testing scrap

Serial no.	Form of rubber.	Washing losses.		Differences.
		Experiment 1.	Experiment 2.	
		Per cent.	*Per cent.*	*Per cent.*
309 . .	Scrap	15·0	14·5	0·5
310 . .	Crêped scrap	1·6	0·9	0·7
311 . .	do.	0·3	0·2	0·1
312 . .	do.	0·1	0·3	0·2
313 . .	do.	nil	0·1	0·1
314 . .	Scrap	2·7	2·2	0·5
315 . .	do.	—	5·4	—
316 . .	do.	5·4	7·0	1·6
317 . .	do.	4·2	2·8	1·4
318 . .	do.	20·5	(2) 18·8 (3) 17·0	1·7 to 3·5
319 . .	do.	16·5	14·8	1·7
320 . .	do.	12·4	11·4	1·0
321 . .	do.	14·3	16·3	2·0
322 . .	do.	17·9	15·1	2·8

rubbers is the difficulty of deciding from mere inspection of the crêpe whether the washing has been sufficient to remove the majority of the impurities present (bark, sand, etc.). The results given in the preceding table show that the washing losses determined in the usual way on different portions of the same sample may vary considerably. These variations may be caused partly by the difficulty of obtaining uniform samples of a scrap rubber, but are more probably due to differences in the extent to which the impurities have been removed.

The differences in washing loss are rather considerable in the case of most of the samples of scrap as collected from the trees, *e.g.* Nos. 316–322; whereas the samples which were washed in Ceylon (Nos. 311–312) show, when re-washed at the Imperial Institute, only small variations in the different experiments.

In order to investigate this question further a sample of mixed scrap rubber was subjected to moderate washing and was then divided into two portions, one of which was subjected to additional prolonged washing. The washed samples were examined with the following results:

	Dirt (insoluble in petroleum ether).	Ash	Sand and silica calculated	
			On ash	On rubber.
	Per cent.	*Per cent.*	*Per cent*	*Per cent.*
Moderate washing .	2·9	1·45	40·5	0·56
Prolonged washing	1·6	0·98	23·1	0·23

It is evident that prolonged washing is necessary for the removal of most of the foreign matter from scrap rubber, and that without analysis it is difficult or impossible to judge the extent to which the impurity has been removed.

The reasons for the irregularity in tensile strength and elongation of different rings from the same slab of vulcanised scrap rubber and the general inferiority of this rubber have been carefully investigated. The causes which appeared most probable were:

(1) Variation in the composition of the rubber, *e.g.* presence of abnormal amounts of resin, protein or ash; or chemical or physical alterations of the caoutchouc itself.

(2) Presence of mechanical impurities such as bark or sand.

With reference to the first point mentioned above, a few typical samples from the present series of scrap rubbers were submitted to chemical examination, and the results are shown in the following table along with those obtained for previous samples of scrap rubber :

Serial no.	Mode of preparation.	Composition of dry washed rubber.			Sand and silica.
		Resin.	Protein.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
	Present samples :				
309	Scrap from trees .	2·15	2·58	3·28	2·35
310	Scrap steamed and then crêped .	2·52	2·24	1·86	not determined
311	Scrap crêped on washing rolls .	2·30	2·09	0·83	not determined
312	Scrap washed in Universal Washer and then crêped .	2·41	2·18	0·69	0·22
313	Scrap steamed, made into crêpe and smoked . .	2·18	1·76	0·91	0·44
	Previous samples :				
2	Scrap from trees	2·55	3·30	1·30	not determined
106	Scrap from trees	3·13	3·28	1·03	do.
30	Scrap from trees	2·98	2·79	1·30	do.
134	Scrap from trees	3·29	3·23	1·10	do.
39	Scrap from trees	2·90	2·81	1·39	do.
225	Scrap from trees	3·86	3·03	1·55	do.
236	Scrap from trees	2·95	2·77	1·55	do.

The amounts of resin and protein present in these scrap rubbers are similar to those in the various grades of latex rubbers, but it will be noticed that all the samples of scrap contain abnormal quantities of ash (mineral matter).

It seemed probable therefore that the inferiority of the scrap rubbers was not due to any variation in composition, but to the presence in the rubber of small particles of bark, sand or earthy matter which might cause minute local flaws in the vulcanised rubber, and so lead to premature rupture of the test rings. Careful examination of many broken test rings failed, however, to disclose any certain evidence of flaws or particles of bark or foreign matter at the point of rupture. Experiments have, however, been

made to determine the effect of adding small quantities of powdered Hevea bark or of mineral matter to a good latex rubber, and have given interesting results.

Addition of powdered Hevea bark to latex rubber

Portions of a sample of good latex rubber were mixed with 0·25 and 0·5 per cent. of powdered Hevea bark, and were then submitted to vulcanisation and mechanical tests in comparison with the original rubber. The following results were obtained :

	Time of cure.	Tensile strength.	Elongation.	Permanent set.	Remarks.
	Minutes.	*lb. per sq. inch.*	*Per cent.*	*Elongation per cent.*	
1. Rubber alone .	65	2,370	880	3·1	Correct cure
2. Rubber + 0·25 per cent of bark .	68	2,250	864	3·6	Slight overcure
3. Rubber + 0·5 per cent of bark .	68	2,200	867	3·7	Correct cure

The above results indicate that the addition to latex rubber of small quantities of finely powdered bark has only a slight influence on the tensile strength and elongation. The rubber even with 0·5 per cent. of added bark is decidedly better than any of the samples of scrap rubber examined, and it seems unlikely that as much as 0·5 per cent. of bark is present in any well-washed scrap rubber.

Addition of mineral matter to latex rubber

In order to investigate the influence of the mineral matter (ash) in scrap rubber, a preliminary experiment was made in which about 1 per cent. of ash (obtained by incinerating a scrap rubber) was added to a latex rubber of good quality during the process of mixing with sulphur in the usual way. This mixture showed signs of becoming soft and tacky on the mixing rolls as scrap rubbers generally do, and gave inferior results for tensile strength after curing.

Further experiments were therefore conducted in which the following additions were made to a good latex rubber : (1) a small quantity of ash from a scrap rubber : (2) the amount of sand and silica present in (1) ; and (3) a quantity of levigated chalk equal to the amount of ash used in (1).

The details of these experiments are given below :

	Blank experiment.	I.	II.	III.
Rubber	90	90	90	90
Sulphur	10	10	10	10
Total ash of scrap rubber .	nil	1·35	nil	nil
Sand and silica	nil	nil	0·86[1]	nil
Chalk	nil	nil	nil	1·35

[1] *i.e. the amount of sand and silica contained in* 1·35 *parts of the ash used in Experiment I.*

The results of the vulcanisation and mechanical tests of these samples were as follows :

		Blank experiment.	I.		II.	III.
Time of cure . .	*minutes*	70	70	73	73	70
Tensile strength .	*lb. per sq. in.*	2,370	1,940	1,870	1,870	2,490
Elongation . .	*per cent.*	868	822	806	854	887

These results indicate that the addition of the ash of a scrap rubber to a latex rubber of good quality reduces the tensile strength considerably (Expt. I compared with the Blank Expt.) ; and that the sand and silica present in the ash alone produce an equally bad effect (Expt. II). The addition of finely divided chalk does not have any injurious effect (Expt. III).

It seemed probable from these experiments that the presence of particles of sand in scrap rubber has a marked influence on their physical properties after vulcanisation. Experiments were therefore made to investigate further the influence on latex rubber of sand of a degree of fineness similar to that of the mineral matter in the scrap rubbers. The mineral matter (ash) occurring in these scrap rubbers varied from 0·71 to 5·89 per cent. and was found to be in a fairly fine state of division, the greater part passing through a sieve of 120 meshes to the inch.

Ground sand of different degrees of fineness was added to a latex rubber of good quality, 1 per cent. of sand being used in each case. Particulars of the samples and the results of the tests are given below :

	Time of cure.[1]	Tensile strength.	Elongation.
	Minutes.	*lb. per sq. in.*	*Per cent.*
1. No sand (Control)	65	2,420	883
2. 1 per cent. sand passing 50, not passing 120-mesh sieve	65	1,885	831
3. 1 per cent. sand passing 120, not passing 180-mesh sieve	65	1,960	849
4. 1 per cent. sand passing 180-mesh sieve	65	2,280	868

[1] *All these samples were slightly overcured at* 65 *minutes, but the degree of overcure is equal in all cases and the results are therefore comparable.*

It is clear from these experiments that the degree of fineness of the sand has a distinct influence on the results, the coarsest sand effecting the greatest reduction in the tensile strength.

As the particles of ground sand passing a 180-mesh sieve (Expt. 4) were much coarser and more angular than the particles of chalk used in the previous Expt. III, an attempt was made to produce sand of extreme fineness by repeated grinding followed by levigation with a gentle current of water. Two samples of very fine sand were obtained in this way, but neither sample was as fine as the chalk, and it appears impracticable to produce sand of the required fineness by this means. Experiments with these samples were, however, made, and the following results were obtained, 1 per cent. of sand being used as in the previous experiments :

	Time of cure.	Tensile strength.	Elongation.	Remarks.
	Minutes.	*lb. per sq in.*	*Per cent.*	
1. No sand (Control) .	65	2,370	874	Very slightly overcured
2. 1 per cent. sand passing 180-mesh sieve, but finer sand removed and used for Expt. 3	65	2,200	854	Slightly overcured
3. 1 per cent. fine sand removed from 180-mesh sieve by levigation . . .	65	2,310	886	Slightly undercured
4. 1 per cent. fine levigated sand, finer than in Expt. 3 .	65	2,290	879	Correct cure

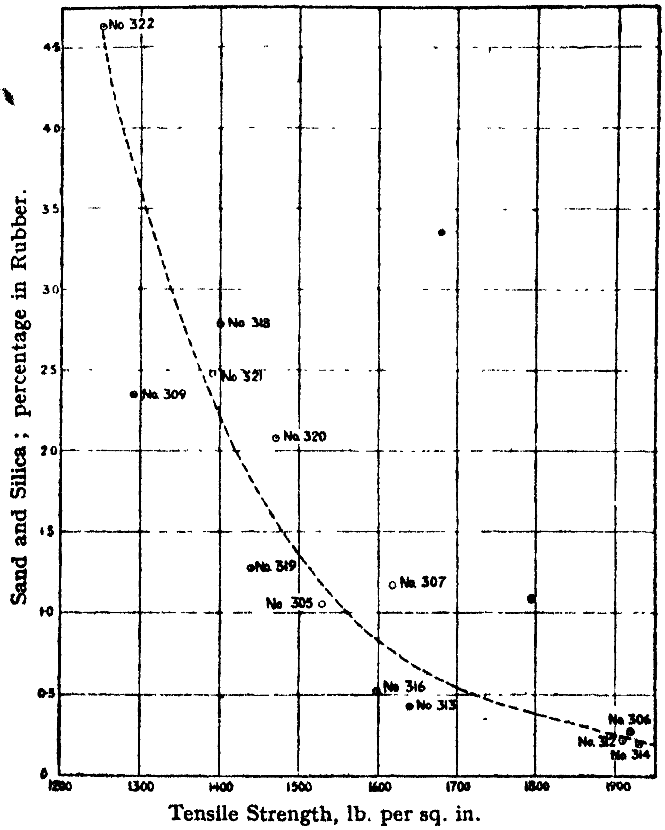
It would therefore appear that the presence of sand of considerable fineness has a marked influence on the tensile strength of good-quality rubber, and that the inferiority of scrap rubbers in this respect is largely due to the presence of particles of sand.

In view of the above results the percentage of sand and silica was determined in a number of the samples of scrap rubber, and it was found that the three samples (Nos. 306, 312 and 314) which had the highest tensile strength contained the lowest amounts of sand and silica, and that in most cases the scrap rubbers of poor tensile

strength contained the largest amounts of sand and silica (see diagram below).

Variable results were given in some cases by different samples of scrap rubber prepared in the same way, and it was usually found that the sample containing the lower percentage of ash had the higher tensile strength. It seems

DIAGRAM ILLUSTRATING THE RELATION BETWEEN THE PERCENTAGE OF SAND AND SILICA IN THE RUBBER AND THE TENSILE STRENGTH OF THE VULCANISED PRODUCT.



probable that the effect of different proportions of ash is of much greater importance than that of different methods of preparation employed, and this should be borne in mind in comparing the results.

Discussion of Results

Most of these scrap rubbers have given comparatively low results for tensile strength and elongation, though

occasionally the figures (*e.g.* Nos. 306, 312, 314) are not much below those for low-quality latex rubbers. The results are similar to those obtained for samples of scrap rubber previously examined at the Imperial Institute, which are shown below for comparison with Table I (page 4):

Serial number.	Form of rubber.	Time of cure. *Minutes.*	Tensile strength. *lb. per sq. in.*	Elongation. *Per cent.*	Permanent set. *Elongation per cent.*
2	Scrap from trees	75	1,620	797	—
106	do. do.	65	1,430	883	—
30	do. do.	70	1,800	832	—
134	do. do.	75	1,730	861	—
39	do. do.	70	1,890	859	—
225	do. do.	85	1,350	830	5·0
236	do. do.	85	1,520	813	4·4

Sections VIII and IX.—Both the samples of bark scrap (Nos. 305 and 309) gave rather poor results in the mechanical tests. They cured more rapidly than the corresponding samples which were washed or otherwise treated in Ceylon immediately after collection. The two specimens prepared by steaming, followed by crêping (Nos. 308 and 310), furnished decidedly poor results, but as a similar sample which was smoked in addition (No. 313) gave a fair result it cannot be concluded that the steaming is the cause of their inferiority.

The sample of crêped scrap in Section VIII (No. 306) gave a very fair result, but a similar sample in Section IX (No. 311) was less satisfactory. One of the specimens washed in a Universal Washer and then crêped (No. 307) gave a rather poor result, but the other sample prepared in this way (No. 312) is one of the best of this series of scrap rubbers.

Section X.—The results of the examination of the scrap rubbers collected at different periods after tapping are irregular, but they do not indicate that scrap rubber deteriorates appreciably when left on the trees for a few days.

Section XI.—The exposure of scrap rubber to light, either in thin layers or piled in a heap, does not seem to have had any marked effect on the properties of the rubber after vulcanisation. All the rubbers in this section contained large amounts of ash and gave low results in the tensile

tests. Sample No. 322, which was left in a heap in sunlight, had the lowest tensile strength; but as it contained far more ash than the other samples, its inferiority cannot be attributed to the method of treatment.

Conclusions

All these scrap rubbers have given low results for tensile strength and elongation. It seems almost certain from the experiments described in this report that this inferiority is due to the presence of foreign matter which cannot be entirely removed by washing; and that of these impurities it is the mineral matter, particularly the particles of sand, which is the chief cause of the defect.

In view of these results it may be suggested that, if possible, methods of collecting scrap should be adopted which will reduce to a minimum the amounts of bark and sand present, particularly the latter, and that the rubber should be thoroughly washed before manufacture to remove the impurities to some extent.

(2) EXPERIMENTS TO DETERMINE THE EFFECT OF SMOKING ON THE MECHANICAL PROPERTIES OF THE RUBBER

SERIES V

Section XII. Effect of Smoking Sheet Rubber for Different Periods

Date of experiment: September 7, 1915.
Percentage of rubber in latex: 27.

No. 323. Unsmoked sheets. Control.
No. 324. Sheets smoked for three days.
No. 325. Sheets smoked for seven days.
No. 326. Sheets smoked for fourteen days.

Sample No. 326 was dry when removed from the smoke-house.

Section XIII. Effect of Coagulating Latex in Smoke-house followed by Subsequent Smoking of the Rubber

Date of experiment: September 11, 1915.

No. 327. Latex was put into pans and left in the smoke-house overnight. By next morning the latex had coagulated. The wet rubber was then removed from the

pans, rolled out into sheet and placed in the smoke-house until dry (14 days).

No. 328. Latex treated as in No. 327, but rolled once only. It was then placed in the smoke-house until the surface was dry (10 days).

Section XIV. Effect of Using Different Fuels for Smoking

Comparative experiments on the effect of using various fuels in the smoking process are difficult to carry out, owing to the fact that estates usually possess only one smoke-house, and it is consequently only possible to smoke one batch of samples at a time. Small temporary sheds can be erected for experimental purposes, but their volume is very small in comparison with an ordinary smoke-house, and the rubber smoked in such sheds is therefore probably subjected to a greater smoke-density than is usual in the ordinary process.

For the present experiments two small smoking-cabinets were used, and the fuels employed were rubber-seed shells and tea-stumps.

No. 329. Sheet smoked with rubber-seed shells.

No. 330. Sheet smoked with tea-stumps.

The rubber was smoked for fourteen days in each case.

Additional Samples

Two samples of rubber, prepared in preliminary experiments, were also included in Series V and were described as follows :

No. 335. Smoke-coagulated latex rolled once.

No. 336. Smoke-coagulated latex. The rubber was not smoked subsequently.

The results of vulcanisation and mechanical tests of these samples are given in Table II.

Remarks on Series V, Sections XII—XIV

The rubbers in these sections were prepared in order to investigate the effect (1) of smoking rubber for different periods, (2) of coagulating the latex with smoke, followed by smoking the rubber, and (3) of using different fuels for producing the smoke.

TABLE II

Results of Vulcanisation and Mechanical Tests

Series V. Sections XII—XVI

	Form of rubber.	Serial no.	Washing loss.	Time of cure.	Tensile strength.	Elongation.	Permanent set.
Section XII. Effect of smoking sheet rubber for different periods.			*Per cent.*	*Minutes.*	*lb. per sq. in.*	*Per cent.*	*Elongation per cent.*
Unsmoked	Diamond sheet	323	0·13	57	2,300	878	2·5
Smoked 3 days	do.	324	0·14	60	2,250	883	3·1
„ 7 days	do.	325	0·24	62	2,370	872	3·2
„ 14 days	do.	326	0·50	68	2,280	873	2·7
Section XIII. Effect of smoke coagulation of latex, followed by smoking of the rubber.							
Latex smoke-coagulated, rolled into sheet and smoked till dry (14 days)	Sheet	327	0·52	57	2,400	886	3·7
Latex smoke-coagulated, rolled once only, then smoked till surface was dry (10 days)	do.	328	0·34	45	2,330	873	4·0
Section XIV. Effect of using different fuels for smoking.							
Smoked with rubber-seed shells	Diamond sheet	329	0·38	65	2,370	880	3·1
Smoked with tea-stumps	do.	330	0·17	65	2,440	873	4·3
Section XV. Effect of evaporating latex in vacuum drier.							
Latex evaporated in vacuum drier		331	1·32	33	2,410	873	4·0
Section XVI. Effect of drying rubber by different methods.							
Air-dried at 85–90° F.	Thin crêpe	332	0·40	115	2,160	875	2·9
Hot-air dried, 2 hours at 135° F.	do [1]	333	nil	118	2,260	868	2·6
Vacuum dried, 1 hour at 140°–160° F.	do.[1]	334	0·10	114	2,230	865	2·5
Additional Samples.							
Smoke-coagulated, rolled once	Sheet (rather thick)	335	2·13	38[2]	2,120	882	3·1
Smoke-coagulated, not smoked subsequently	Sheet (rather thick)	336	0·18	53	2,300	879	2·9

[1] *The crêpe had formed a solid slab 1½ to 2½ inches thick and could not be unwound.*

[2] *Slightly undercured; sample too small to repeat test.*

The results obtained with the samples prepared by smoking the rubber for different periods in comparison with those given by the control sample (Section XII) showed that the treatment produced an increase in the time of cure, the extent of which depended on the duration of the smoking. Thus the unsmoked control sheet cured in 57 minutes and the sheet smoked for 3, 7 and 14 days in 60, 62 and 68 minutes respectively. This result is in general agreement with those obtained previously for smoked rubbers, but the increase in the time of cure is not so marked as in some of the earlier samples where smoking almost doubled the time of cure. The present smoked samples show some variation in tensile strength, but do not differ markedly in this respect from the control sample.

The two samples of Section XIII, which were prepared by coagulating the latex in the smoke-house, and then smoking the rubber, cured fairly rapidly, the times being 57 minutes for No. 327 and 45 minutes for No. 328. In the latter case the rubber was rolled only once, and then smoked until the surface was dry, whereas No. 327 was smoked until quite dry. The fact that No. 328 was left in a partially moist condition no doubt explains the more rapid rate of cure. There was no control sample in this section, but the tensile strengths of the two specimens were normal.

Two additional samples made in preliminary experiments on the smoke coagulation of latex were also forwarded: viz. No. 335, "Smoke-coagulated latex, rolled once"; and No. 336, "Smoke-coagulated latex. The rubber was not smoked subsequently." These samples differed rather widely in time of cure (38 and 53 minutes), but the details of preparation supplied are not sufficient to explain this variation or to permit these samples to be considered in relation to those of Section XIII. The greater rapidity of cure of No. 335 may, however, be due to the fact that it retained more moisture than No. 336, as shown by the greater loss on washing.

The rubbers treated with the smoke from rubber-seed shells and tea-stumps respectively (Section XIV) showed little variation. They both cured in the same time and agreed closely in tensile strength.

(3) Experiment to determine the Effect of Evaporating Latex in a Vacuum Drier on the Mechanical Properties of the Rubber

Series V

Section XV. Effect of Evaporating Latex in Vacuum Drier

The latex from several fields was bulked for this experiment, and the rubber was prepared over a series of days.

No. 331. The latex, containing approximately 35 per cent. of dry rubber, was placed in a pan in a Passburg Vacuum Drier. The water did not evaporate readily as a skin of rubber formed on the surface of the latex. The temperature of the drier is usually about 140° F.

The results of the vulcanising and mechanical tests of this rubber are given in Table II (p. 15).

This sample, No. 331, was dealt with in a previous Report (this Bulletin, 1916, **14**, 550), where its exceedingly rapid rate of cure (33 minutes) was fully discussed. Unfortunately no control sample from the same latex is available for comparison.

(4) Experiments to determine the Effect of Different Methods of Drying on the Mechanical Properties of the Rubber

Series V

Section XVI. Effect of Drying Rubber by Different Methods

Date of experiment: September 21, 1915.

The latex from several fields was bulked and coagulated, and the rubber converted into thin crêpe. The crêpe was then divided into three portions which were treated as follows:

No. 332. Air-dried. Temperature 85–90° F.
No. 333. Hot-air dried. Two hours at 135° F.
No. 334. Vacuum dried. One hour at 140–160° F.

These rubbers were submitted to vulcanising and mechanical tests, the results of which are included in Table II (p. 15).

These samples, representing rubber dried (1) in the air at 85° to 90° F., (2) in hot air at 135° F., and (3) in a

vacuum drier at 140° to 160° F. all gave very similar results, and there is no indication that the different methods of drying exert any appreciable influence on the rate of cure or tensile strength. All the samples, however, gave rather irregular results on vulcanisation. The samples consisted of thin crêpe and, like previous specimens of rubber prepared in this form, were slow curing (114 to 118 minutes) and the tensile strengths were rather low.

(5) Large-scale Experiments to determine the Effect of Different Methods of Preparing Rubber on the Mechanical Properties of the Rubber

Series VI

The majority of the samples of this series were prepared with the object of ascertaining whether rubber made under estate conditions would give similar results to the small-scale specimens of Series I and II. The methods of coagulation adopted were those of the estate on which the rubber was made.

The latex was the bulked product of trees of thirteen years of age and less. No water was added to the latex before the addition of acid.

Dilute acetic acid (approximately 5 per cent.) was added to the latex in the proportion of one part of pure acid to one thousand parts of pure latex. The mixture of acid and latex was then poured into long troughs, and the coagulum rolled out next morning.

The method of rolling the sheets was similar to that adopted in the samples of Series I and II (see this Bulletin, 1916, **14**, 498), except that the last rolling was done with a diamond-marked roller.

The percentage of dry rubber in the latex was between 35 and 40 per cent. The samples were prepared during May and June 1916.

Note.—The samples were prepared on different days, and numbered in various sections. On the completion of the series, the factory coolies without instructions scrubbed the samples in accordance with the practice on the estate. In this way many of the labels giving particulars of the dates of preparation, etc., were lost, and

the samples could therefore not be divided into sections as usual.

Serial No.	*Description.*
337	Plain unsmoked sheet.
338	Sheet smoked three weeks.
339	Sheet smoked three days.
340	Sheet smoked seven days.
341	Sheet smoked fourteen days.
342	Plain sheet smoked two days and made into roll.
343	Sheet put through rollers once, smoked two days and made into roll.
344	Plain sheet. Acid added to latex without stirring.
345	Diamond sheet. Acid added to latex without stirring. Not smoked.
346	Diamond sheet. Acid added to latex without stirring. Smoked two weeks.
347	Latex coagulated with acetic acid. Coagulum neither machined nor smoked.
348	Latex coagulated with acetic acid. Coagulum not machined, but smoked three weeks.
349	Diamond sheet. Unsmoked.
350	Diamond sheet smoked two weeks.
351	Crêpe unsmoked.
352	Crêpe smoked two weeks.

The object of the preparation of Nos. 344, 345 and 346 was to ascertain whether the quality of sheet rubber varies at different points of the sheet if the acid and the latex are not mixed efficiently. The diluted acetic acid was poured along one side of each trough, and the side of each sheet of rubber corresponding to the side on which the acid was added was marked.

The results of the vulcanising and mechanical tests of these rubbers are given in Table III (p. 20).

Remarks on Series VI

For the reason already given, these samples which were prepared on different days could not be divided into the usual sections, and it will consequently only be possible to deal with the results in a general way.

The series includes a number of comparative samples of smoked and unsmoked rubber, viz. Nos. 337–341 and Nos. 349–352. In these samples the smoked rubbers had a longer time of cure than the unsmoked, the times of cure of the smoked rubbers ranging from 75 to 85 minutes as compared with 60 to 68 minutes for the unsmoked control samples. The variation in tensile strength was only small.

TABLE III

Results of Vulcanisation and Mechanical Tests

Series VI

	Form of rubber.	Serial no.	Washing loss.	Time of cure.	Tensile strength.	Elongation.	Permanent set.
			Per cent.	*Minutes.*	*lb. per sq. in.*	*Per cent.*	*Elongation per cent.*
Unsmoked sheet	Sheet	337	0·35	67	2,200	868	2·5
Sheet smoked 3 weeks	Sheet	338	0·43	80	2,170	875	2·9
Sheet smoked 3 days	Diamond sheet	339	0·37	75[1]	2,200	885	3·4
Sheet smoked 7 days	do.	340	0·44	75	2,230	880	3·4
Sheet smoked 14 days	do.	341	0·41	75	2,200	880	3·0
Sheet smoked 2 days, made into roll	Moist smoked sheet, rolled up	342	2·07	66	2,330	870	2·3
Sheet rolled once, smoked 2 days, made into roll	do.	343	3·4	60	2,270	878	3·1
Plain sheet, acid added to latex without stirring	Sheet	344	0·50	50	2,200	873	3·2
Diamond sheet, do., not smoked	Diamond sheet	345	0·18	53	2,340	874	3·2
do. do., smoked 2 weeks	do.	346	0·17	75	2,190	875	2·9
Coagulated with acetic acid, neither machined nor smoked	Slab ⅛ in. thick	347	8·50	40	2,260	873	3·5
Coagulated with acetic acid, not machined, but smoked 3 weeks	Slab ⅛ in. thick	348	10·75	35	2,180	872	3·9
Diamond sheet, not smoked	Diamond sheet	349	0·95	60	2,250	874	3·6
do., smoked for 2 weeks	Diamond sheet	350	1·10	85	2,110	872	3·9
Crêpe, not smoked	Crêpe (blanket)	351	0·25	68	2,240	875	2·9
Crêpe, smoked for 2 weeks	Crêpe (blanket smoked)	352	0·63	85	2,150	866	3·1

[1] *Slightly undercured.*

The two samples of moist sheet, smoked two days and made into rolls (Nos 342 and 343), cured in 66 and 60 minutes respectively, the quicker cure of the latter specimen being probably explained by the fact that in this case the sheet was only rolled once, and therefore no doubt remained in a moister condition.

Two specimens of slab rubber, Nos. 347 and 348, were as usual very quick curing, taking only 40 and 35 minutes respectively. In this connection it is noteworthy that the quicker-curing sample (No. 348) had been smoked for three weeks, whereas No. 347 was unsmoked. It is not easy to account for this fact, since as a general rule smoking increases the time of cure, but probably the smoke only affects the surface layers in thick moist slab rubber.

With reference to samples Nos. 344, 345 and 346, which were prepared by adding acetic acid to the latex without stirring, a comparative examination was made of portions (A) of the sheet from the side on which the acid was added and portions (B) from the opposite side. The results are shown in the following table :

	Time of cure. *Minutes.*	Tensile strength. *lb. per sq. in.*	Elongation. *Per cent.*	Permanent set. *Elongation per cent.*
No. 344 A . . .	50	2,200	871	3·2
B . . .	50	2,210	875	3·1
No. 345 A . . .	53	2,330	876	3·3
B . . .	53	2,350	868	3·1
No. 346 A . . .	73	2,210	874	3·1
	75	2,200	863	—
B . . .	75	2,180	875	2·8

It is evident from these figures that the rubber from the two sides of the sheets shows no appreciable differences either in time of cure or tensile strength.

General Conclusions on Series V, Sections XII—XVI, and Series VI

Most of these samples were prepared in repetition of previous experiments, and the results generally confirm those already recorded. It is evident (1) that smoking usually lengthens the time of cure of sheet rubber without markedly affecting the mechanical properties of the rubber ; (2) that different methods of drying have little effect on

the vulcanising and mechanical properties; (3) that rubber allowed to remain in a moist condition is quick curing; and (4) that thin crêpe rubber cures slowly, whereas blanket crêpe approximates in this respect to ordinary sheet.

CINCHONA BARK FROM EAST AFRICA AND THE CAMEROONS

In a previous article in this Bulletin (1918, **16**, 370) entitled "The Future of the Trade in Cinchona Bark," it was mentioned that in addition to Java, India and Ceylon, whence cinchona bark is now chiefly obtained, cinchona trees have been introduced into other parts of the tropics, and an account was given of the results of examination of samples of bark from St. Helena and the former German Colony in East Africa. Since that date a consignment of bark from East Africa and four samples from the Cameroons have been examined at the Imperial Institute, and these are described in the present article.

East Africa

The manufacturers to whom the first samples of East African bark were submitted for valuation expressed a desire to purchase a shipment of the bark, and in 1919 a consignment was forwarded to the Imperial Institute by the Acting Administrator of German East Africa.

The consignment consisted of 52 bags of cinchona chips (net weight 61 cwts. 0 qr. 27¾ lb.), which were apparently derived from *Cinchona succirubra*, and 1 bag of quills (net weight 60 lb.), which more resembled the *C. Ledgeriana* type of bark.

Samples of the chips and the quills were submitted to chemical examination at the Imperial Institute with the following results:

	Chips. Per cent.	Quills. Per cent.
Moisture	8·8	10·9
Total alkaloids	5·86	4·46
Including quinine [1]	1·81	3·39
[1] *Equivalent to crystalline quinine sulphate*	2·45	4·61

It will be seen from these figures that the total alkaloid present in the quills amounted to 4·46 per cent., and was mainly quinine, whereas the chips contained 5·86 per cent. of total alkaloid, of which, however, only 1·81 per cent. was quinine.

The chips were purchased by the manufacturers at 5½*d.* per lb., and the quills at 11*d.* per lb.

The consignment of chip bark contained less quinine and less total alkaloid than the sample of *C. succirubra* bark from German East Africa which was received at the Imperial Institute in 1918. The latter material yielded 3·39 per cent. of crystalline quinine sulphate compared with 2·45 per cent. from the present consignment.

The quills resembled the *C. Ledgeriana* bark examined in 1918 in yielding about the same amounts of quinine and total alkaloid.

The results of the investigation confirm the view that cinchona bark of good quality can be grown in German East Africa, although the two samples of *C. succirubra* bark have shown variation in the amounts of total alkaloid and quinine present. It would therefore appear desirable to take steps to extend the plantations of the trees, particularly those of the *C. Ledgeriana* type, with a view to the production of bark for British manufacturers.

Cameroons

Cinchona has been produced from experimental plantations established by the Germans at Buea in the Cameroons, and four samples of bark from these plantations were received from the Government of Nigeria for examination at the Imperial Institute in 1918.

It was stated that the samples were obtained by stripping the bark from the trees and drying it in the sun.

Sample No. 1 was collected from trees growing at an elevation of about 3,000 ft.; samples Nos. 2 and 3 were from a plantation about 200 ft. higher up the Cameroon mountain, and No. 4 was from a plantation at a still higher altitude.

The four samples were similar in appearance, and consisted of quilled pieces of natural bark, about 20 in. in length, from ¾ to 1½ in. in width and from ⅛ to ⅜ in. in

thickness. The outer surface was in many cases covered with lichen. The inner surface was dark reddish-brown and the fracture was light brown.

The barks were analysed at the Imperial Institute with the following results :

	No. 1. Per cent.	No. 2. Per cent.	No. 3. Per cent.	No. 4. Per cent.
Total alkaloids . .	7·5	6·3	7·0	8·3
Moisture . . .	9·9	10·2	10·3	10·1

As the value of cinchona barks of these types depends chiefly on the amount of quinine obtainable by the process used by the quinine manufacturer, samples of the barks were submitted to a British firm of quinine manufacturers for further examination and valuation. The following results were obtained :

	No. 1. Per cent.	No. 2. Per cent.	No. 3. Per cent.	No. 4. Per cent.
Quinine alkaloid . . .	6·14	5·05	5·27	5·28
Cinchonidine	0·55	0·24	0·23	1·17
Yield of crystalline quinine sulphate .	8·19	6·73	7·02	7·04

These results show that all the samples are of good quality, furnishing from 6·7 to 8·2 per cent. of quinine sulphate, and consignments of similar quality would be very suitable for the manufacture of quinine sulphate.

As regards the value of the barks from the Cameroons, the pre-war value of cinchona barks was about 1*d.* per lb. per unit per cent. of quinine sulphate, but the price for delivery up to the end of 1918 was 2*d.* per lb. per unit. The value at the end of 1918 and the pre-war value of the barks on this basis are shown in the following table :

Sample.	Value at end of 1918. Per lb.	Pre-war value. Per lb.
No. 1	1*s.* 4*d.*	8*d.*
No. 2	1*s.* 1½*d.*	6*d.* to 7*d.*
No. 3	1*s.* 2*d.*	7*d.*
No. 4	1*s.* 2*d.*	7*d*

It appears probable that samples 1, 2 and 3 were derived from the "Ledger type" of cinchona, whilst sample 4 was probably derived from a hybrid.

The results of this investigation show that these cinchona barks from the Cameroons are of good quality, as they furnish more quinine sulphate than average cinchona bark from Java, which is now the principal source of supply. It is possible, however, that when the trees are regularly

stripped for the production of bark, the percentage of quinine may be diminished.

In submitting this report to the Governor-General of Nigeria it was requested that information should be furnished to the Imperial Institute as to whether commercial samples of these barks could be furnished from the Cameroons Province, and if so the quantities available. It was also pointed out that it would be of interest to learn the species of Cinchona from which the samples were derived. In response to this request the following information has been received.

According to the Director of Agriculture, "Commercial, but not large, quantities of these barks could be supplied from the Cameroons Province. It would be necessary to re-examine the plantations in the light of this Report in order to determine the possible output. In any case, that from the plantation from which Sample No. 3 was obtained would be very small, as this plantation has been neglected in recent years, so that many of the trees have died, and the others are badly grown for the greater part." He added that a nursery of over 500 plants had been made at Buea, which was making good progress in July 1918.

The Resident, Buea, at a later date, however, reported that the present quantity of trees would not furnish commercial supplies of cinchona bark. He had taken the opinion of the Acting Supervisor of Plantations and the Manager of Molyko Plantation, both of whom had been familiar with cinchona trees in Ceylon, and they state that all the trees in question are of the Ledger variety. The Resident further states that there are no other quinine trees in the Province, either in the Botanical Garden at Victoria, or among the plantations.

CANDLENUTS FROM THE COOK ISLANDS, NEW ZEALAND

The sample of candlenuts (*Aleurites* sp.) which is the subject of this report was forwarded to the Imperial Institute by the High Commissioner for New Zealand, in August 1919.

It was desired to ascertain the value of the nuts as a

source of oil and the suitability of the residual cake for use as a feeding stuff.

Appended to this report is a memorandum furnished by the Imperial Institute to the High Commissioner on the preparation of candlenut kernels for export. The production of candlenuts and candlenut oil is now an industry of some importance in the Philippine Islands, and an account of the industry was given in the last number of this BULLETIN (1919, **17**, 591).

The sample examined at the Imperial Institute consisted of ordinary candlenuts (*Aleurites* sp.), which were dry, but in rather a mouldy condition externally, whilst about 13 per cent. of the nuts contained shrivelled or decomposed kernels. The nuts consisted of shell 68 per cent., and kernel 32 per cent. The average weight of the sound nuts was 11·0 grams, and of the kernels 3·5 grams.

The sound kernels extracted from the nuts contained 4·5 per cent. of moisture and yielded 63·7 per cent. of a pale yellow oil, equivalent to a yield of 66·7 per cent. of oil from the dry kernels. The oil was examined with the following results, which are shown in comparison with the figures obtained at the Imperial Institute with previous samples of candlenuts from Hong Kong and Mauritius.

	Present sample.	From Hong Kong.	From Mauritius.
Specific gravity at 15°/15° C.	0·928	0·927	0·927
Acid value	1·3	1·72	—
Saponification value[1]	194·8	204·2	193·7
Iodine value . . . *per cent.*	158·5	139·7	151·0
Refractive index at 40° C.	1·4703	—	—

Preliminary drying tests showed that the untreated oil dried very slowly, but that it gave rather better results after being heated. On heating the oil with driers its drying properties were considerably improved, and then compared favourably with those of raw linseed oil.

The foregoing results show that the present consignment consisted of candlenuts of normal character.

Candlenut oil is a "drying oil" suitable for the manufacture of paints and soft soap. Its purgative properties prevent it being used as an edible oil, whilst the residual cake is similarly unsuitable for use as a cattle food, and is only saleable at a low price as a manure.

Candlenuts appear to have been crushed occasionally in small quantities in the United Kingdom in the past, but they have not become a regular article of commerce in this country, and the oil is not well known on the market. In the United States, on the other hand, candlenut oil produced in the Philippine Islands meets with a ready demand. There is no reason to doubt that both the oil and the kernels would sell readily in the United Kingdom at the present time if fairly large and regular supplies were offered at suitable prices. It would most likely be unprofitable to ship the entire nuts, as they only contain about 20 per cent. of oil, and even with the prices now ruling for oils the high freight rates would probably render the export of the nuts unremunerative. The kernels might, however, be shipped, and should realise about £40 to £44 per ton in the United Kingdom with linseed at £54 per ton.

The authorities have been asked to furnish information as to the possibility of forwarding commercial consignments of candlenut kernels from the Cook Islands.

The Preparation of Candlenut Kernels for Export

The chief difficulty in the exploitation of candlenuts is that of shelling the nuts. The shells are hard, whilst the kernels are rather brittle and tend to cling to the shell, so that although it is not difficult to crack the shells it is difficult to avoid breaking the kernels into small pieces, which often adhere to portions of the broken shells.

In the Philippine Islands various methods are stated to be employed, which may be summarised as follows:

(1) The nuts are dried by exposure to the sun for several days, and are then cracked by hand with a hammer or stone, the kernels being picked out by hand with the help of a knife. By this method kernels of good quality are obtained, but the process is tedious and is only possible when cheap labour is available. The kernels broken in this operation should not be included with the whole kernels for shipment, as they would deteriorate in transit and lower the value of the consignment.

When treated by this method at the Imperial Institute an average sample of the Cook Island nuts yielded about 20 per cent. by weight of whole kernels in good condition,

and 5 per cent. of broken kernels in fair-sized pieces, which in actual practice could be shipped separately and sold at a lower price than the whole kernels.

(2) The nuts are placed in large quantities on the ground, and covered with straw, which is then burnt, and the nuts immediately sprinkled with cold water. The shells of the nuts are stated to burst and thus allow of the extraction of the kernels.

(3) The nuts are stated to be " placed in tanks of boiling water and left there for five to six hours" (it is not clear if the water is kept boiling all the time) ; " this loosens the kernel," and the nuts are then cracked. This method (with continuous boiling) was tried on a small scale at the Imperial Institute, and about 75 per cent. of the kernels were obtained either entire or in large pieces when the nuts were cracked by hand, and about the same proportion when the nuts were passed through a Miller nut-cracking machine. It would not appear that the kernels are much loosened in the shells by the boiling water, but they are rendered more tough and flexible, and less brittle than those of the untreated nuts. Unfortunately the kernels are darkened in colour by the process and are said to yield a dark oil inferior to that from sun-dried kernels. The process does not appear to offer much advantage over the shelling of sun-dried nuts by method No. 1 described above, and it involves extra labour, as well as the drying of the kernels after extraction.

(4) A method developed by the Bureau of Science in the Philippine Islands consists in heating the nuts in an oven for 3 to 4 hours at 95° C., and then placing the nuts in cold water and leaving them there overnight, when the shells are said to burst. This method was tried on a small scale at the Imperial Institute, but about 40 per cent. of the nuts did not burst, and when they were split with a hammer the kernels in these nuts were found to be brittle and broken in pieces. The method therefore does not appear to be very satisfactory.

On the whole it seems that method No. 1, *i.e.* the hand-shelling of sun-dried nuts, is the most likely to prove generally useful, though it is possible that some of the other methods may be more feasible with freshly gathered nuts

than with nuts which, as in the present case, have been collected and kept for some time.

It would be quite practicable to grind up the entire nuts and either express the oil or extract it by solvents; but this would almost certainly have to be done on the spot, as the shipment of the entire nuts would not be likely to be remunerative. This method would, however, have certain disadvantages, *e.g.*:

(1) More presses would be required for a given output of oil.

(2) The oil would probably be inferior to that from the extracted kernels freed from shell, and the yield of oil would be less.

(3) The value of the residual cake as a manure would be lower than that of cake obtained by treating the kernels alone.

If the entire seed were worked, the extraction of the oil by solvents would be preferable to expression, as a higher yield of oil would be obtained.

THE COMPOSITION AND VALUE OF MINERALS FROM MOROCCO

In connection with the investigations conducted by a Commission sent out by the Department of Overseas Trade as to the possibilities and conditions of trade between Morocco and the United Kingdom, a number of minerals were forwarded to the Imperial Institute for examination and report in April 1919. Further samples were received from Morocco through the Department of Overseas Trade, in May, October, and November, 1919. The results of examination at the Imperial Institute of the more important of the minerals are given in the following pages. A summary of the Commission's Report, including a brief account of the mineral resources of Morocco, is given on pages 97–111 of this Bulletin.

Iron Ores

Samples Nos. 1–4, below, were stated to have been obtained from the neighbourhood of the Atlas Mountains.

No. 1.—This sample was analysed with the following results :

		Per cent.
Ferric oxide	Fe_2O_3	83·23 [1]
Ferrous oxide	FeO	1·28 [1]
Titanium dioxide	TiO_2	0·30
Silica	SiO_2	5·54
Copper	Cu	0·45
Nickel	Ni	nil
Sulphur	S	0·08
Phosphorus	P	0·04
Loss on ignition		5·17

[1] *Together equivalent to* 59·2 *per cent. of metallic iron* (*Fe*).

This material represents a good-quality iron ore which would be suitable for smelting, and for the production of steel by the acid Bessemer process, although the quantity of phosphorus is slightly above the maximum amount usually considered permissible in the United Kingdom for the latter purpose.

No. 2.—This consisted of iron oxides (hæmatite and limonite) together with a little quartz. On analysis the following results were obtained :

		Per cent.
Ferric oxide	Fe_2O_3	87·31 [1]
Ferrous oxide	FeO	0·90 [1]
Titanium dioxide	TiO_2	0·40
Silica	SiO_2	5·70
Sulphur	S	trace
Phosphorus	P	0·014
Loss on ignition		3·39

[1] *Together equivalent to* 61·81 *per cent. of metallic iron* (*Fe*).

This was a good-quality iron ore, suitable for the production of a good pig iron, and for the manufacture of steel by the acid Bessemer process.

No. 3.—This sample consisted of hæmatite which on analysis gave the following results :

		Per cent.
Ferric oxide	Fe_2O_3	95·95 [1]
Ferrous oxide	FeO	1·04 [1]
Titanium dioxide	TiO_2	0·20
Silica	SiO_2	1·60
Sulphur	S	0·06
Phosphorus	P	0·01
Loss on ignition		0·69

[1] *Together equivalent to* 67·98 *per cent. of metallic iron* (*Fe*).

This was a high-grade iron ore suitable for the produc-

tion of pig iron or for the manufacture of steel by the acid Bessemer process.

No. 4.—This sample consisted of hæmatite, with some quartz and a small amount of cupriferous matter. It was analysed with the following results :

		Per cent.
Ferric oxide	Fe_2O_3	77·11 [1]
Ferrous oxide	FeO	0·81 [1]
Titanium dioxide	TiO_2	0·32
Copper oxide	CuO	0·20
Zinc oxide	ZnO	nil
Nickel oxide	NiO	nil
Antimony oxide	Sb_2O_3	nil
Silica	SiO_2	13·65
Sulphur	S	0·062
Phosphorus	P	0·013
Loss on ignition		1·95

[1] *Together equivalent to* 54·6 *per cent. of metallic iron* (*Fe*).

The amount of silica present in this sample was somewhat high for an iron ore, but the material might be used locally for smelting.

No. 5.—From El Hawatt in Beni Said.

The sample consisted of brown hydrated iron ore containing some quartzose impurity. It was analysed with the following results :

		Per cent.
Ferric oxide	Fe_2O_3	80·72 [1]
Ferrous oxide	FeO	nil
Manganous oxide	MnO	4·96 [2]
Titanium dioxide	TiO_2	nil
Silica	SiO_2	4·14
Sulphur	S	0·03
Phosphorus	P	0·022
Loss on ignition		10·11

[1] *Equivalent to* 56·50 *per cent. of metallic iron* (*Fe*).
[2] *Equivalent to* 3·85 *per cent. of metallic manganese* (*Mn*).

This was a good-quality iron ore, suitable for the production of pig iron and for the manufacture of steel by the acid Bessemer process. The ore might also be used for the manufacture of spiegeleisen, but the product would contain rather less manganese than is usually required.

No. 6.—From D'har D'Shaib, between Anasel and Tsamrabitz, in Beni Said (Tetuan).

This was a sample of manganiferous iron ore with thin

veins of quartz. It was analysed with the following results :

		Per cent.
Ferric oxide	Fe_2O_3	73·22 [1]
Ferrous oxide	FeO	nil
Manganous oxide	MnO	4·99
Titanium dioxide	TiO_2	nil
Alumina	Al_2O_3	1·02
Lime	CaO	1·32
Magnesia	MgO	0·37
Silica	SiO_2	10·14
Phosphorus	P	0·03
Sulphur	S	0·09
Loss on ignition		8·92

[1] *Equivalent to* 51·25 *per cent. of metallic iron* (*Fe*).

This was a fairly good quality manganiferous iron ore, suitable for the production of pig iron or low manganese spiegeleisen. The pig iron might possibly be used for the production of steel by the acid process, but it would contain a somewhat larger percentage of phosphorus than is usually allowed in iron intended for this purpose.

No. 7.—From Gebel Ewaharan, near the village of Ewaharan in Beni Said. The specimens were from the surface at about one kilometre from the sea-shore.

This was a sample of ferruginous quartzose material, which on analysis gave the following results :

Ferric oxide	Fe_2O_3	*per cent.*	65·80 [1]
Manganese oxide	Mn_3O_4	*per cent.*	1·92
Gold	Au		trace
Silver	Ag	*grains per ton*	12·5

[1] *Equivalent to* 46·01 *per cent. of metallic iron* (*Fe*).

This material contains too much silica to permit of its exportation as an iron ore, but it might be used for smelting locally. The quantity of precious metals present is not sufficient to add to the value of the ore.

Specimens from El Mah del Hauwat, near the village of Kerdidda in Beni Said (Tetuan) and about 1 kilometre distant from Gebel Ewaharan, mentioned under No. 7 above, and from El Ferrishah, near the village of Handanet Temncodet in Beni Said (Tetuan), were generally similar to sample No. 7.

No. 8.—From Emerzokan, near Tsamrabitz in Beni Said, very near the sea-shore.

This was a compact manganiferous iron ore, with some

quartz. On breaking the specimens for analysis a small crystal of autunite was seen, but careful search failed to reveal any further evidence of this material.

The material was analysed with the following results :

		Per cent.
Ferric oxide	Fe_2O_3	70·28 [1]
Manganous oxide	MnO	4·17
Titanium dioxide	TiO_2	trace
Silica	SiO_2	16·15
Phosphoric anhydride	P_2O_5	0·02
Sulphuric anhydride	SO_3	0·03

[1] *Equivalent to* 49·16 *per cent. of metallic iron* (*Fe*).

This ore contained rather too much silica to permit of its being remuneratively exported to Europe. The pig-iron or low manganese spiegeleisen obtainable by smelting the ore would, however, be suitable for the production of steel by the acid process.

Nickel Ores

No. 1.—From the neighbourhood of the Atlas Mountains.

This sample consisted of two small fragments, one green and nickeliferous, the other brown and ferruginous.

An analysis was made on a representative portion of the entire sample and gave the following results :

		Per cent.
Nickel oxide	NiO	24·60 [1]
Copper oxide	CuO	nil
Lead oxide	PbO	nil
Zinc oxide	ZnO	nil
Ferric oxide	Fe_2O_3	25·31 [2]
Cobalt oxide	CoO	1·12
Manganous oxide	MnO	2·38
Arsenious oxide	As_2O_3	19·74 [3]

[1] *Equivalent to* 19·34 *per cent. of nickel* (*Ni*).
[2] *Equivalent to* 17·72 *per cent. of iron* (*Fe*).
[3] *Equivalent to* 14·95 *per cent. of arsenic* (*As*).

This material, if available in quantity, would be of value as a source of nickel.

No. 2.—From Seba Lowajit in Beni Bouzera, Ghomara, near the sea-shore. The specimens were stated to be from the surface of a hilly region in which no previous mining had been carried on.

This sample consisted of pyrrhotite, accompanied by some biotite and pyroxene and small amounts of other minerals, including monazite. It was analysed with the following results :

			Per cent.
Copper	Cu		0·77
Iron	Fe		38·90
Nickel	Ni		3·63
Cobalt	Co		0·37
Silica	SiO_2		15·88
Cerium earths	Ce_2O_3, etc.		trace
Platinum metals	Pt, etc.	*grains per ton*	7·8
Gold	Au		nil
Silver	Ag	*grains per ton*	3·88

Lead, zinc and manganese were absent.

This material compares favourably as regards the amount of nickel present with the nickeliferous pyrrhotites worked in the Sudbury district of Canada, but the percentage of copper is much lower, as also are the amounts of silver and platinum metals. If ore of the quality of the present sample is available in sufficient quantity, its working on a commercial scale would prove remunerative.

Manganese Ore

From the neighbourhood of the Atlas Mountains.

This specimen consisted of black manganese oxide, which on analysis gave the following results :

		Per cent.
Manganous oxide	MnO	1·33 [1]
Manganese dioxide	MnO_2	85·84 [1]
Ferric oxide	Fe_2O_3	0·30
Lead	Pb	0·89
Copper	Cu	trace
Sulphur	S	0·13
Phosphorus	P	0·05
Silica	SiO_2	0·69

[1] *Together equivalent to* 55·26 *per cent. of metallic manganese* (*Mn*).

The above analysis indicates a fairly good quality manganese ore, suitable for the manufacture of ferromanganese, but containing rather less manganese dioxide than is usually considered desirable for material intended for use in dry batteries. The ore would be quite suitable for use in chemical manufactures.

Lead Ore

From the neighbourhood of the Atlas Mountains.

This consisted chiefly of galena (lead sulphide). On analysis the following results were obtained :

		Per cent.
Lead	Pb	67·45[1]
Copper	Cu	trace
Iron	Fe	1·02
Manganese	Mn	trace
Silica	SiO_2	1·25
Gold	Au	nil
Silver	Ag	8 oz. 10 dwt. per ton

[1] *Equivalent to 77·87 per cent. of lead sulphide (PbS).*

This was a good-quality lead ore, free from objectionable impurities.

Copper Ore

From the neighbourhood of the Atlas Mountains.

This was a specimen of ferruginous and calcareous gossan with a little copper. It was analysed with the following results :

		Per cent.
Zinc oxide	ZnO	trace
Copper oxide	CuO	1·93[1]
Lead oxide	PbO	nil
Ferric oxide	Fe_2O_3	39·01[2]
Gold	Au	6 dwt. 3 grs. per ton
Silver	Ag	1 oz. 2 dwt. 21 grs. per ton

[1] *Equivalent to 1·54 per cent. of metallic copper (Cu).*
[2] *Equivalent to 27·30 per cent. of metallic iron (Fe).*

This material might possibly be worked profitably for copper and gold.

General Conclusions

It will be seen that several of the mineral samples dealt with in the preceding pages are of promising character. In the case of iron ores Nos. 1–4, nickel ore No. 1, and the manganese, lead and copper ores, the samples examined were small, and consequently it will not be safe to assume that the results of the analyses represent the average composition of the deposits. The presence of monazite in the nickel ore from Seba Lowajit (No. 2) is of interest, and it was suggested that it might be worth while to examine any heavy sands found along the neighbouring

sea-shore or river-beds in order to ascertain if this mineral occurs in workable quantities.

The occurrence of a uranium mineral (autunite) in the iron ore from Emerzokan (No. 8) is of interest, as uranium minerals (which are the chief commercial source of radium) occur in quantity in only a few places. It was recommended therefore that a further examination of this locality should be made in order to ascertain whether autunite occurs in sufficient amount to be worth working.

GENERAL ARTICLES

THE CULTIVATION AND PREPARATION OF COCOA

An article entitled "Cocoa Production in the British Empire," which was published in this Bulletin (1919, **17**, 40), gave an account of the varieties of cocoa cultivated, an outline of the method of preparation of the raw product for the market and a detailed account of the production of cocoa in all countries of the Empire where the crop is grown as well as of the trade in the product in the chief consuming countries. The present article deals with the various aspects of the cultivation and preparation of cocoa, and the pests and diseases which attack the tree. As in the case of the previous article the Imperial Institute is indebted to Mr. A. H. Kirby, Assistant Director of Agriculture in the Southern Provinces of Nigeria, for the preparation of this article, and to Mr. G. C. Dudgeon, C.B.E., formerly Inspector of Agriculture for West Africa, who has again kindly given considerable assistance in revising certain sections.

Cultivation of Cocoa

Climate

Temperature.—As cocoa is essentially a tropical plant, it will not grow successfully where low temperatures are fairly frequent or at altitudes that bring such temperatures; in the latter connection experience in Java has shown that the plant may rarely be expected to thrive in situations that are higher than 1,800 feet above sea-level. The best results are obtained where the temperature very

rarely falls more than two or three degrees below 68° F. or rises more than the same extent above 90° F.

Rainfall.—Little can be said about the effect of the rainfall of a country, with respect to its usefulness for cocoa production, until something is known about the nature of the soil, and the distribution of the rainfall over the different parts of the country and in the different periods of the year. In any case, the precipitation is too great for the healthy growth of the plant when it approaches or exceeds 200 inches in a year. The conditions that are more directly bound up with the effect of rainfall are: (1) the depth of the soil; (2) its composition; (3) the humidity of the air, and (4) the average daily amount of bright sunshine. A deep soil helps to ameliorate the conditions arising from a small rainfall by providing a large volume of soil for the collection of water by the roots; a "heavy" soil or one containing a large proportion of humus assists in the same way by holding water, whilst the rain falling on a light sandy soil runs quickly through it and away. In regard to the third condition mentioned, the humidity of the air, a lack of rainfall is compensated by a high content of moisture in the atmosphere. The latter condition is specially favourable to cocoa, which is one of the most sensitive of cultivated plants to sudden or great changes in the amount of water vapour in the air surrounding the leaves. Lastly, where the average daily amount of bright sunshine is lessened through overcast conditions of the sky throughout a large part of the year, a state that obtains particularly where the presence of mountains is combined with an insular (or maritime) climate, the plant is enabled to resist the effects of a comparatively small rainfall and of drought, not only because of the lessening of the drying effect of continuous direct sunlight, but through the greater humidity of the overclouded atmosphere.

The unfavourable effects of a lack of precipitation are increased by a very unequal distribution throughout the year, or even by the general daily receipt of early showers, followed by drying sunshine; whilst on the other hand, these very conditions will serve to decrease the untoward results of a heavy precipitation.

It is very rare, however, that the natural conditions are such that the plant develops easily and prolifically with little preparation for its growing or control of the state of its environment, and the cultivation of cocoa is concerned largely or mainly with the alteration of this environment in ways that will lead to the best possible vitality and productiveness of the plant. The effects of lack of rainfall are combated by the choice of sheltered situations for planting, the use of shade and the provision of windbreaks, cultivation and care of the soil, and even the employment of irrigation, which is to be found to a greater or less extent in several countries, notably in Venezuela, San Thomé, San Domingo, Nicaragua, Colombia and Guadeloupe. Against an excess of rainfall, on the other hand, the chief remedy is found in drainage, increasing in complexity from the simple clearing of the natural watercourses to the adoption of the elaborate system of canals needed in the heavy, low-lying soils of Surinam, and having for its object the admission of air to the soil as much as the removal of water.

Altitude.—It has been indicated that the question of altitude in cocoa growing is connected more directly with temperature than anything else. At heights approaching 1,800 feet above sea-level the temperature of the air and soil is insufficient for the needs of the plant, although there are instances where a greater elevation is tolerated, notably in a few situations in Venezuela at more than 2,500 feet. Under conditions where the air is likely to be dry, that is where the humidity is less than that needed for the best cocoa growing, an advantage may sometimes be gained by making the plantations in sheltered places sufficiently elevated to provide a lowering of the temperature at night which increases the amount of moisture in the air.

Wind-belts

As cocoa is likely to suffer more severely from exposure to wind than from any other cause, the provision of windbreaks or shelter-belts is necessary where there is no natural shelter from the prevailing wind ; it must be remembered, however, that even these are useless in positions swept by a strong, long-prevailing wind or by sea breezes, and that

no attempt should be made to grow cocoa in such places. Where forest land is being used for cocoa planting, it may be possible to leave belts of the original forest standing for the protection of the cocoa, although in such a case the planter has to reckon with the chances of damage from falling trees, and from the presence of areas providing conditions favourable for a continuous supply of pests and diseases that may attack the cocoa. The best plan seems to be to leave sufficient of the natural covering of the land for the object of general protection, and to plant wind-breaks for supplying the localised shelter that is needed. It is evident, however, that the question of utilising as a wind-break any forest cover that may exist has to be decided on the merits of each case; and where the cocoa is likely to be subjected to the force of hurricanes or tornadoes there is much to be said for the policy of using for the purpose the native trees that have already shown themselves capable of providing the necessary resistance.

As the plants need protection from the wind as soon as they are placed in their permanent positions, it is necessary that, where wind-belts have to be planted, the first trees used shall be quick growers. As, however, the wood of such trees is usually short in fibre and brittle, they do not last long, and the plan has to be adopted of planting at the same time belts of stronger and more lasting kinds in positions where these will replace the others when the time of their usefulness is past.

Many leguminous trees are employed largely as wind-breaks, not only because they are well suited for the purpose of making protective belts, but because their roots may extend into the soil occupied by other plants without lessening the supply of nitrogen to these. Others, such as Para rubber (*Hevea brasiliensis*) and the Central American rubber tree (*Castilloa elastica*), are used for the reason that they may be made to yield some product, besides timber, that is of commercial value; but they are doubtfully useful for this double purpose as they do not themselves possess the capacity to resist very strong winds. Among plants that are adapted for the special purpose, and are at the same time useful in several ways on the plantation, the bamboo takes a high place, particularly for adding to

the shelter where belts are formed of tall trees that possess few low branches; but it suffers disadvantage in that it requires constant periodical attention, so that its roots may be prevented from spreading. One of the most effective trees used as a wind-break is the mango, which in Central America, especially in Nicaragua, is grown as a hedge plant in its first years so that it branches below, finally forming a dense belt of strong-wooded trees.

Plants used in shelter belts are either raised in nurseries and planted during the wet season in holes made at their permanent positions, in the way described later for cocoa, or seeds of them are sown at stake in the places prepared for them. The former of these methods is the better, as proper care in carrying it out gives better plants and ensures more readily a stand of uniformly developed trees. The after-cultivation of the plants is chiefly concerned with the removal of weeds that may smother the seedlings or cause them to grow spindly, topping to encourage low branching, and later the close pruning of injured branches and the treatment of wounds with antiseptic materials.

Provision of Shade

Cocoa is provided with two kinds of shade: temporary shade, preferably from short-lived plants, when it is young; and permanent shade from trees when it is older. Temporary shade may be considered to be always necessary, although in one or two countries such as Brazil and Ecuador it is not employed. Such shade must be supplied so as to be effective from the moment that the young cocoa begins its life in its permanent position. In the simplest way, the shade is given by leaving some of the forest trees when the partial clearing of the plantation is made, or, when cocoa is put out in old plantations that have been used for raising similar trees, such as coffee, the original permanent shade trees are left. These methods are not recommended, as they provide shade that is insufficient, and the plants raised under it are not strong or of good shape. The plants used for supplying temporary shade may be: (1) short, broad-leaved kinds, such as species of *Colocasia* and *Xanthosoma*, known familiarly as tannias, eddoes, taro and coco-yam; (2) plants forming bushes or small trees, such

as cassava, the pigeon pea, the castor oil plant, the lamtoro (*Leucaena glauca*) and others, which have to be removed if they are wanted only for temporary shade, and (3) broad-leaved plants of larger growth than the first-mentioned kind, such as the banana and the plantain. There is much difference of opinion about the comparative usefulness of some of these, as the degree of success gained by their employment has naturally varied under the different conditions in which they have been tried. In countries where cocoa has been grown for some time as a staple crop, it is best to follow the local practice; in those where the growing of cocoa is in a comparatively early stage, it is well to consult the Agricultural Department. In the employment of the plants mentioned for the purpose it is usual to employ one or more of the smaller-growing kinds together with the banana or plantain; cassava is favoured by some, as it may be made a source of profit by the sale of its roots, although it possesses the disadvantage that it is an exhausting crop and shows a success that varies much with the nature of the soil; whilst the banana and plantain yield marketable fruits and open up the soil, the banana being superior in the latter respect.

In practice, the smaller temporary shade plants (generally cassava or tannias) are placed three or four in number, at the beginning of the wet season, around and close to the holes that have been dug for the cocoa, in the way described later, during the preceding dry season. The bananas are put in about 12 or 15 feet apart, and the plantains somewhat nearer together than this, between the rows of cocoa holes, the plan often being to arrange for one of the shade trees to be placed in the middle of each group of four cocoa holes. The best time of planting is at the end of the dry season or at the beginning of the wet season, and the stations for the plants should have been well forked before the latter sets in. These courses ensure that the smaller plants are sufficiently large to shade the cocoa when it is put in, and when the cocoa grows taller the time has come for them to be removed so that their duty may be fulfilled by the bananas (or plantains), which have then had the opportunity to grow to a size useful for the purpose.

There has been much discussion among authorities as to whether permanent shade is necessary for successful cocoa cultivation. On the whole it may be stated that permanent shade is usually necessary throughout the life of the cocoa tree, and where the plant is grown successfully without it, as in Grenada, Brazil and San Domingo, as well as on certain estates in Surinam and Trinidad, special conditions are present, *e.g.* the nature and treatment of the soil, which render shade unnecessary. These conditions have been most closely studied in Grenada (see, especially, Van Hall's *Cocoa*, pp. 148, 356 and 358), and the best conclusion seems to be that in this island an effect similar to the beneficial action of permanent shade in protecting the soil is brought about by the tillage that is nearly always given there to plantation cocoa, whilst this protection is assisted by the comparatively close planting of the trees, their distance apart being mostly less than 12 feet. The large applications of pen manure that are favoured on most of the plantations in that island doubtless assist in an important way the ameliorating effect of good tillage and the protection resulting from close planting; and cocoa cultivation in Grenada affords one of the many examples of the fact that the keeping of stock forms a part of a successfully balanced agricultural system.

Circumstances like those spoken of are exceptional, however, and it may be taken as a fact demonstrated both by the experience of planters and by experiments that permanent shade must be provided for cocoa under ordinary conditions. In old plantations in some parts of the world, notably Ecuador, Central America, San Thomé, the Gold Coast and the Belgian Congo, some of the forest trees occupying the planted areas have been left for the purpose, further protection being derived from the close planting of the cocoa. This plan, however, does not give the kind of shade that is needed in the regularly arranged modern plantation, and the employment of trees that have been proved useful for the purpose is a matter of general recommendation. In the various countries different trees are used; but they are nearly always leguminous, notable exceptions being afforded in Ceylon where there is an

increasing tendency to interplant with Para rubber, and in Java where silk-cotton or kapok is a favourite tree for inter-planting so that there may be a possibility of direct profit from the shade tree.

The beneficial effects of shade trees are concerned not so much with the protection of the cocoa from the sun as that of the soil in which it is growing; this protection consists in the prevention of quick drying and of the action of direct sunlight in bringing about the speedy and useless decomposition of the humus whose presence is so especially important in tropical soils. Their usefulness is further derived firstly from the action of their roots in opening up the soil and, as they are usually leguminous, in adding to the supply of nitrogen; and secondly from the provision of humus from the falling leaves in the dry season. The fallen flowers, too, of those planted most commonly in the Old World, viz. species of *Erythrina*, have been proved to yield an appreciable amount of humus containing a high proportion of nitrogen.

Plants for permanent shade are raised and planted out by the methods that are described later for cocoa. Various ways of arranging for the distribution of the shade trees among the cocoa are employed, and here again local practice and the results of experiments conducted in the country form the best guides for the planter. A simple plan is to put a shade tree in every third hole in the lines of holes (see below) prepared on the plantation, so that the shade trees mark the corners of squares whose sides measure three times the distance between the cocoa plants; or to put a shade tree similarly at the middle position between the plants in every third group of four cocoa seedlings.

When Para rubber or kapok is employed, the process takes the nature of mixed planting rather than planting for shade, the two kinds of plants being at the same distance apart, and the trees being spaced at greater intervals than when the cocoa is planted in rows under leguminous trees employed solely as shade.

The after-care of permanent shade trees is mainly a matter of pruning for obtaining the most useful shelter from them, the removal of branches that are likely to damage the cocoa beneath them by falling, the removal

of plants (epiphytes) that grow on the trunk and branches, and the protective treatment of wounds.

Soil and Situation

Soils of very different character are tolerated by cocoa, and rare instances are known where this toleration extends to those containing a small amount of salt, although it only exists where the plants have become accustomed to the conditions, for the access of brackish water to a plantation always causes much damage to the cocoa. The fact that the plant is grown successfully on varying kinds of soil has led to much patient investigation of the nature of the mineral or chemical limiting factors for its growth ; but little has been found so far which will show how the analysis of a soil serves as an indication of its usefulness for a cocoa plantation. The most favourable soils are those with a good capacity for holding water and a high content of humus, combined with good drainage and depth ; although lack of depth may be compensated for by the existence of underlying rock that is well broken. The presence of an impervious sub-soil is very unfavourable, while shallow soils resting on unbroken rock are useless. The best lands are those which have not been cultivated previously, or have rested with a natural cover for many years. Soils showing any excess of one characteristic, such as dryness, wetness, heaviness, sandiness or a rocky nature, are avoided ; whilst the most favourable conditions are afforded by deep alluvial soils that can be well drained.

Regarding situation, one of the first matters that decide the suitability of a site for a cocoa plantation is that of shelter, particularly where there are strong or lasting winds ; but steep mountain slopes, even if they afford this shelter, are avoided on account of the severe weathering and washing of the soil that take place on them. Soil washing is also an unfavourable feature on hill slopes, but cocoa is cultivated successfully on such slopes if they are on the sheltered side, and provided with a system of contour drains. Another condition that governs the selection of land for cocoa is the existence of good natural drainage. Further, as has been indicated already, high

elevations are to be avoided, as well as old estate lands that have been exhausted by the raising of annual crops on them.

Propagation

The usual method is to raise the plants from seed in nurseries, but planting at stake is sometimes employed. The former is the more expensive because of the labour entailed, and much loss of plants often arises because of carelessness in planting out; but it has the advantage in that weak seedlings may be rejected and a reserve is available for replacing plants that fail, so that a more regular stand is obtained. The fact that cocoa seeds have to be sown when they are quite fresh makes it impossible to raise seedlings at stake where the time of fruiting is succeeded by severe or continued dry weather. In planting at stake, three or four seeds are sown at the permanent stations of the plants at about 9 inches from one another, and the best seedling in each group is allowed to survive. The irregularity that is likely to occur through the failure of all the seedlings at some of the stations may be corrected by supplying from a nursery in which seeds were sown at the same time as the sowing at stake was done.

Methods of vegetative propagation, which include grafting, budding and layering or marcotting, have not been adopted to any extent on cocoa plantations, although they have proved the subject of much interesting experimentation at several agricultural stations. They are of value from the circumstance that they provide a means of ensuring that the cocoa planted is of exactly the kind that is wanted, and not mixed in character by hybridisation. If these methods are ultimately proved to give plants that can be depended upon to yield suitably under estate conditions, they will be of the greatest use and importance.

The Making of the Nursery.—On large plantations several nurseries are made on sites that drain easily and where the soil is lightest. This is well forked and made into beds about five feet wide with two-foot paths between them; the soil is well broken up and mixed with compost or pen manure in the dry season. The shade is provided by placing palm leaves on light branches supported on posts put firmly in the ground about 8 feet apart.

In districts where the fruiting of the cocoa is followed by severe dry weather care is taken to place the nurseries near a water-supply in order to reduce expenditure on labour needed for carrying the water and to ensure thoroughness in watering.

The drainage of the nurseries is a matter of much importance, and is carried out by means of a number of small drains rather than a smaller number of large trenches; a trench of any size is only needed for carrying away the water from the small drains that run into it.

Selection and Sowing of Seed.—The seed for propagation is chosen from trees that are healthy, and have been proved to yield the largest and most regular crops; and all small or immature pods are rejected. As the pods selected are opened, those seeds borne near the ends of the fruit are rejected, only the large fully-formed seeds being kept for planting. These are cleaned and then rolled in dry earth, ashes or slaked lime, to protect them from insect attack. They are sown at a distance of 6 inches or 1 foot, at a depth of about an inch, in rows 1 foot apart.

Sometimes for greater security in transplanting the seedlings are raised in the nursery in native-made baskets or in bamboo pots, preferably standing on a bed of loose stones. The bamboo pots are made by cutting well-grown bamboos into lengths of about a foot, so as to leave each piece with one of the dividing walls of the stem near one end; the solid end thus provided forms the bottom of the pot, which is pierced with a hole to let out water. For convenience in removing the seedling at the time of transplanting, the pot may be split lengthwise into two pieces which are tied together again in their original positions.

For the reception of the seeds, the baskets or pots are filled to within an inch of the top with soil from the nursery after a layer of stones covered with coconut fibre or coarse, dry grass stems has been placed at the bottom of each of them. The employment of baskets in this way is of much convenience, as will be seen later; but the attraction that they possess for white ants forms a disadvantage, and the soil in the baskets easily becomes dry and weakens or kills the seedlings.

The sowing of seeds at stake has been partly described

already. The seeds need the same treatment as those put into nursery beds, baskets or pots, and are sown at the same depth.

After-care in the Nursery.—Where there is insufficient rain the chief matter of care is watering, especially during the time immediately after the seeds have begun to germinate. When storms have thinned or removed the nursery cover, this should be replaced as soon as possible. The soil is kept clear of weeds, and if its surface becomes hard it is carefully hand-forked between the seedlings. In some cases the good effect of this hand-forking is assisted by spreading a thin layer of old compost or well-rotted pen manure over the beds when the plants have become established as seedlings.

Cocoa rarely suffers severely from pests or diseases in the nursery, although under unfavourable conditions it is likely to be attacked by several of those mentioned below, notably, among animal pests, rats, the mole cricket and the parasol ant where this is found, and among fungoid diseases the Surinam witch broom, and horse-hair blight when it is grown in bamboo pots. Means of protection and remedies against these are described in the section dealing with pests and diseases; and it will be seen that these are applied more easily for plants in nurseries than for those grown at stake. The labourers and others working in nurseries should always be trained to look out for injurious insects and to destroy them by crushing or dropping them into water containing a small quantity of kerosene, and to remove sickly seedlings or parts of them. Fungoid diseases are encouraged in nurseries by too dense shade, too copious watering and by want of drainage. As the palm-leaf shade generally used is easily removable, it is best to reduce this in cloudy weather, and in any case to lessen the shade as the plants become older, in order to harden off the seedlings to some extent, so that they may bear better the more rigorous conditions consequent on transplantation.

Preparation of the Land

Forest lands are cleared during the dry season by first cutting down the shrubs and smaller trees, and putting

them into heaps for burning, and then felling the large trees and cutting them into lengths for burning in their turn. Where an estate is laid out in areas of a few acres each, palm stems and the larger timber are rolled to the edges of the roads separating those areas, care being taken to keep the road drains clear, and are left for one or two seasons, until they are sufficiently rotten and dry to burn easily. As has been shown already, it is the best plan to remove all trees rather than to leave any of them for the purpose of supplying shade. When the smaller plants are being cut for clearing, sufficient of the stem should be left for marking the places where their underground parts remain; these are then dug out—a process known as stumping—and mixed in heaps with the dry wood for burning. The thorough removal of these stumps is advisable as they interfere with the work of planting the cocoa; and as many of them remain alive when left in the ground, they add to the expenses of weeding by continually sprouting during the wet season. The removal of the largest stumps is not so urgent: their presence causes a certain amount of irregularity when the rows come to be planted; but it is not until the cocoa is a few years old that they are likely to act as centres of infection of diseases that have power to attack the crop.

It is well recognised that burning the cover in this way often destroys the tilth of the soil and robs it of the humus and much of the mineral matter that it would receive if the wood and timber were allowed to rot while lying upon it. Burning is, however, the only expeditious way of removing the cut and felled cover, so that it may be out of the way of the operations of cultivating and planting, and of preventing it from acting as a place of shelter for the continual production of pests that are inimical to cocoa. Nevertheless, the loss of humus that takes place through burning may be reduced by saving the smaller stuff and collecting it into compost heaps distributed among the different sections of the plantation so that it may help to supply material readily available for later manuring and mulching.

The clearing of new land is followed by the planting of one or more annual crops that will protect the soil and thus

lessen the loss of humus that would otherwise follow the removal of the natural cover. These crops are sometimes such as will yield a return for their produce in the local markets; sometimes leguminous crops grown for their protective power, and the prevention of washing of the soil, and of the growth of weeds; and often a combination of the two kinds. At this time the land is lined out, the lines being about 12 feet apart where the soil is not rich or no permanent shade is used, and at least 15 feet where it is rich and trees used for the purpose of shading only are to be put in.

The places where the lines cross are marked by stakes to indicate the stations for planting. At each of these during the dry season, either the soil is well forked or, in heavy soils and where the water table is low, pits at least 2 feet across and 2 feet deep are dug, the soil from them being heaped on the lower side of the pits if the ground is sloping. If it is intended to plant permanent shade trees at special stations, these must be prepared in the same way at the same time. The preparation of the land is followed by the planting of the temporary shade by the methods described already.

Transplanting

This is done during the wet season, but if possible not when the soil of the fields is very wet or sodden. The seedlings, which have been allowed to grow to a height of about 18 inches, are given a thorough watering the evening before they are lifted or (if they are in baskets or pots) moved for transplanting. In some cases it is the practice to lift those that come from nursery beds in which the soil is heavy with the roots still embedded in most of the soil that they occupy, and care is taken to keep the mass of soil unbroken; whilst seedlings from light soil have their roots gently washed in water or in liquid mud; in others, much less trouble is taken, the seedlings being lightly shaken to remove most of the soil adhering to the root and planted just as they are or with about one-third of the tap root cut off with a sharp knife. The experience of planters decides which of these methods is best suited to the special circumstances. Care is taken to have all preparations made

for planting the seedlings in their new positions, and they are carried to these as quickly and with as little exposure as possible.

When the cocoa is planted at stations that have been simply forked, enough of the soil for the reception of the seedling, as it comes from the nursery, is removed a few days before planting. For planting in holes the soil taken from them is mixed with well-rotted compost or pen manure, and packed lightly below and around the seedling. Seedlings in baskets are planted without removal from them; plants in bamboo pots are removed carefully before being planted, the pots being split if necessary for the purpose. The depth to which the seedlings are put is such that they stand out of the soil to the same extent as they did in the nursery. Seedlings do not usually receive any artificial support after being planted out; but it is wise to provide this for budded or grafted plants by tying them to sticks pushed firmly into the ground beside them.

Seedlings are sometimes protected by the erection of temporary shades made of palm leaves, as soon as they are planted out; or in the case of planting at stake, the shades are made when the seeds are sown. These should not be required if the temporary shade plants have been put in long enough before for them to become efficient protectors when the cocoa is planted.

Weeding and Tillage

Weeding is done by cutlassing or hoeing, care being taken not to defer it and allow the weeds to become thoroughly established in the plantation. Hoeing is much more effective than cutlassing; but care is needed in carrying it out, especially on established plantations, whilst its employment on steep slopes will generally lead to damaging loss by soil washing. The method is particularly useful for young cocoa, and where the soil is heavy.

The weeding of cocoa has been a subject of much discussion among planters and experimenters [1] and the method adopted must depend primarily upon the conditions of the plantation and the way in which it is made.

[1] *Cocoa*, Van Hall, 1914, pp. 153 to 160, may be usefully consulted in this connection.

The constant and complete removal of weeds, generally known as clean weeding, is not often practised on cocoa plantations. It is doubtless the cheapest form of weeding, and its adoption is likely to be found the best plan where there is good shelter and humus supply from the shade trees. If this method is adopted the weeds should be removed at first, not less often than once every fortnight, but it will soon be found that weeding will not be necessary as often as this. In any case, where good shade is used, the amount of weeding is bound to become less when this has become effective. When it is decided to adopt clean weeding on an old plantation, the weeds are killed by giving frequent hoeings during a dry season.

The weeds are put into rows or heaps, to rot and provide mulch or compost later ; they should not be raked up round the plants, or they are likely to assist infection with disease by causing dampness at the collar. The spreading of weeds after they are cut or hoed is often advocated, but there is difficulty in this method in that some of them quickly take root again if they are not killed by heaping or composting.

The methodical tillage of cocoa soils is comparatively rare, but it will usually be found to be beneficial on heavy soils. Where it is done it usually consists of very careful forking between the trees, during the first part of the dry season, in such a way as to leave a space of untouched ground measuring at least 6 feet across around each tree. The forking is only followed by hoeing in very heavy soils. In some cases the main roots of the cocoa are cut through where they come into the forked area. This procedure is likely to cause injury to the trees where much dry weather is experienced, although the unfavourable effect may be lessened by only forking alternate lengths between the rows.

Where there is a severe dry season, or where the shade is absent or thin, the soil is sometimes assisted to retain its water by chopping it with the hoe in such a way as to disturb only the surface of the soil.

Mulching.—The use of the light material removed in clearing the land and of that provided by weeding has been mentioned already. In addition, grass and weeds

and light woody material from adjacent land are sometimes applied as mulch. These possess a manurial value in addition to their power of conserving the water, improving the physical properties of the soil and keeping down weeds. The large quantities required, however, postulate the existence of large adjacent areas to draw from and of cheap labour or other means of transport. Mulching may be assisted by providing enclosures for compost near the cocoa fields and filling them with the material as it becomes available. In countries where labour is scarce at certain times of the year, this plan supplies a means of using it to the best advantage when it can be obtained, and reduces the amount needed at the time when mulching has to be done.

Mulching is carried out when the dry season is coming in. On heavy soils the efficiency of the mulch is made greater by a light hoeing or forking of the surface of the soil just before the material is applied.

Drainage

On very good land cocoa tolerates bad drainage, and even temporary inundations, provided that the water is moving and does not become stagnant. In such cases, however, there is no doubt that the plants would receive benefit and remain longer in profitable bearing if proper systems of drainage were introduced. The kind and degree of drainage depends naturally on the slope of the land and the nature of the soil. Slopes that are not steep and from which the water runs away by means of a good natural outfall are not usually drained artificially. In the case of steep slopes, it is necessary to cut drains running across the slope, mainly for the purpose of preventing the serious loss that is brought about through the washing of the soil by flood waters, and, where the land is heavy, for aerating the soil. Where the drains run across the steep slopes with very little fall they are known as contour drains.

The draining of less sloping lands or those that are nearly flat requires systems that are more complex ; these are seen in their greatest intricacy in Surinam, where cocoa is grown in heavy land along the banks of tidal rivers. When cocoa is to be grown in such situations, the levels of the ground should be surveyed accurately, and holes should

be dug at various places for the purpose of ascertaining the height of the water table during the wet season. The drains employed are trenches, rectangular or triangular in cross section; the latter possess an advantage in that their sides are less likely to fall in, and they do not need cleaning so frequently. They should be made when the cover crops or catch crops are put in after the clearing of the land; if made later the growth of these crops is likely to be interfered with. All such drains must communicate freely with an outflowing stream or outfall channel, or the cocoa will be in danger of injury from excessive soil water from time to time, and both they and the means of outfall need careful inspection at the beginning of the rainy season and during its course, in order that they may be cleaned if necessary.

Catch Crops

As has been mentioned already, annual crops suitable for local consumption may be raised on the land as soon as it has been cleared. This is the only way in which catch crops can be raised on the cocoa plantations where the banana is used for shade or where permanent shade of the ordinary kind is employed. Where there is no shade, or when lighter shade, such as kapok or Para rubber, is used, intercrops may be grown successfully, for a time at any rate. Maize, cassava, sweet potatoes, bananas, plantains, leguminous annuals such as peas, beans and ground nuts, peppers (capsicums), lemon grass and cotton are among those grown in different countries, but several of these are of very doubtful utility as intercrops with cocoa.

Manuring

Much discussion has taken place among those who grow cocoa either for commerce or experimentation, both as to the kinds of manure that should be used and the methods by which it should be applied. There is general agreement, however, as to the usefulness of mulches, composts or pen manure; whilst the employment of artificial manures has been comparatively rare. The use of the latter is likely to increase in extent as more comes to be known regarding their effect and as plantations become older. The local Agricultural Departments, which now exist in practically

all countries, should be consulted for the results that have been obtained by experimentation, and assistance can be obtained from them in formulating manurial plans and trials on the plantation.

The application of mulch, compost or pen manure may be looked upon as always safe for cocoa cultivation, and the use of the last-named is necessary for the best crops where there is no shade, as in Grenada. This useful manure would doubtless be employed for cocoa much more generally than is the case at present, if it were not for the impossibility of obtaining it in quantity in many countries and the difficulty of transport owing to its bulk. It has been pointed out already that the island just mentioned affords the best example of the combination of cocoa growing with animal production. In Java, too, pen manure is prized on cocoa plantations; it is, however, often rather poor material, bought cheaply from neighbouring villages.

The chief artificial manures that are in use or trial for cocoa are basic slag, superphosphate of lime, sulphate of potash, sulphate of ammonia and nitrate of soda. Dried blood and cotton-seed meal which, owing to their richness in plant food constituents, may be classed with the artificial manures, have been experimented with, but have not so far been used in cultivation to any extent; lime also has received attention in experimentation. The quantities of these that are convenient for use, each on an area of one acre, are: basic slag 4 cwts.; superphosphate of lime ½ cwt.; sulphate of potash 1½ cwts.; sulphate of ammonia 1 cwt.; nitrate of soda 1 cwt.; dried blood 4 cwts.; cotton-seed meal 5 cwts.; lime, as chalk or slaked lime, ½ ton. These quantities are mostly those rather of heavy applications than otherwise, and it is always to be remembered that the employment of such manures in cultivation should be a matter of the greatest caution, their use and proportionate quantity being primarily dependent on the nature of the soil to which they are to be applied. Basic slag has often shown itself a good manure for cocoa; in addition to being a phosphatic manure it acts partly as a supplier of lime. Sulphate of potash is not usually needed on soils containing much clay. Sulphate of ammonia has given indications of being better than nitrate of soda as a

source of nitrogen for cocoa, but such manures are not usually required, owing to the general use of mulch and compost and the presence of leguminous shade trees which enrich the soil in nitrogen. The existence of these trees must, on the other hand, be considered in relation to the supply of phosphate and potash, manurial substances for which they may show a need as the plantation gets older. Where the shade is not too heavy, green manure crops, such as Crotalaria, may be grown and turned in. Lime, particularly quicklime, which, however, is rarely in use even for trials, should be used with the greatest caution, and in any case it would only need to be used at intervals of several seasons.

The cocoa plant usually forms a large number of surface rootlets in addition to the roots that go deeply into the soil, and owing to the possibility of damaging these it is inadvisable to bury the manure completely. The best plan appears to be to give the surface of the soil a light forking or hoeing before the manure is applied ; even this is not necessary in the case of mulch, compost or pen manure on the lighter soils. It is best to mix artificial manures with dry soil before they are applied to the land, partly to assist in spreading them and partly to lessen the chance of their being washed away during showers. On no account should manures of any kind be scattered or spread near the stems of the cocoa plants.

The usual time for applying manures is at the end of the dry season ; but if fruits are being formed at this time, the use of nitrogenous manures must be delayed until there is no danger that they will stimulate vegetable growth at the expense of the fruits.

Pruning

The following kinds of pruning are in use on cocoa plantations : (1) for the useful production of leaves, (2) for symmetry, (3) for protection, (4) for the improvement of old trees, (5) for quick renewal in stations occupied by old, decaying or damaged plants, and (6) for fruit production.

Pruning for the useful production of leaves and that for symmetry are of the same kind, for it is only in a plant of regular growth that the leaves are disposed in such a

way that they make the best use of the light and air that are necessary for their work. This pruning begins when the seedlings are young, and consists then in the pinching-off of buds or developing branches so as to leave no more than three or four primary branches borne regularly on one main stem. When the plants are older, sappy branches, known variously as "suckers," "watershoots," "chupons" and "gourmands," arise, especially near the base of the stem and below places where damage has occurred ; except in special circumstances, which are mentioned later, these are to be removed. At any time in the life of the plant, when one or more branches tend to grow longer than the rest, these should be removed or pruned to an extent which will prevent them from becoming a source of weakness through disproportionate growth. Pruning for symmetry may be also taken to include the removal of twigs in the middle of the tree, to admit light and air, and of branches that tend to grow downward and interfere with the work on the plantation ; there is necessity for care in these kinds of pruning, to prevent their being carried out to such an extent as to lead to an unbalanced production of leaves near the ends of the branches.

Pruning for protection should be regarded as the most important kind that is carried out on the plantation. Its purpose is the prevention of the spread of disease, and for this reason it is sometimes referred to as the cleaning of the trees. It comprises the careful and regular removal of dead and dying wood, and of decaying pods, from the trees, and for it to be of use, all dead and dying branches, as well as dead trees, must be taken away at the earliest opportunity and burned, whilst the pods should be buried, preferably with lime. The work needs care, and is done best by training a gang for the special purpose, and sending it through the plantation at regular intervals during the dry season when there are no fruits forming on the trees. Allied to this work of protection, and indeed part of it, is the heaping of the cocoa husks when these are opened on the field, so that in the heating of their fermentation and rotting any organisms of disease that might otherwise live and spread may be killed. A better method of dealing with the cocoa husks is to open them at a place away from

the growing cocoa, and to make compost heaps of them with lime, but it is not always possible to arrange for labour to do this.

Pruning for the improvement of old trees is one of the means employed when it is desired to better the conditions and increase the crop on an old or neglected plantation. It consists of the careful removal of all weak and decaying parts of the trees in the way just described, and of the encouragement of a sucker from near the base of the stem of a feebly-bearing or damaged tree so as to form a new tree as quickly as possible. The one sucker that is allowed to remain is treated like a seedling, being pinched out to form no more than four regular primary branches ; and the old wood is removed by degrees by light prunings at frequent intervals.

Regarding pruning for fruit production, all the modes of treatment just described tend indirectly to promote the production of fruit. There is, however, a direct method of manipulation that has been known to be employed when the vegetative life of a tree is so disproportionately active that branches and leaves rather than fruits are being formed. This condition may arise in rich soils or where quantities of nitrogenous manures have been used ; and the treatment consists in digging a trench round the plant at such a distance as to cut through the chief lateral roots, and thus decrease their power to absorb.

In all kinds of pruning no instrument should be used that entails anything in the nature of chopping or hacking ; a saw is necessary for heavy pruning, and a pruning knife with a serrated edge, or the ordinary kind made as sharp as possible, is needed for the lighter work. In removing large branches, the first cut is made upwards, from underneath, to prevent the branches from tearing long wounds in the stem. In all ordinary pruning the branch should be removed as close to the stem as possible, so that butts may not be left to die back and introduce disease. Wounds caused by pruning are trimmed to a flat, even surface and treated with some substance such as tar, coloured resin oil or clay to shield the severed surfaces from infection by disease.

Work similar to pruning, and best done by the gangs

that carry out this, is the cleaning of the trees from plants that use them as a site for growing (epiphytes) and those that feed on them as well (parasites). The removal of the latter, which consist chiefly of kinds of mistletoe, is the more difficult work; it is in fact a kind of pruning, as it entails the removal of tissue, and it requires quite as much care as that process. In carrying it out the chief points to remember are to cut away a liberal quantity of the wood and bark on either side of the place where the parasite is seen, and to make the cut clean and treat it with some protective substance in the way that is followed for pruning.

The time for pruning is after the end of the harvest and during the dry season. It has been stated that the work is best done by labour that is specially skilled for the purpose. This labour should cover the ground frequently, carrying out the work on any one tree in small amounts at a time, so as to give it an opportunity to recover from the wounding completely on each occasion before it receives the next visit. Where there is much of the work to be done, and only a few skilled labourers are available for it, the treatment of the trees in part of the plantation should be delayed rather than that any of the plants should receive severe pruning in order to economise time.

Harvesting

The time at which the trees come into useful bearing, as well as their yield, depends on the kind of cocoa and the conditions in which it is grown: Forastero bears earlier than Criollo, and unshaded cocoa before shaded plants, although the time of useful bearing is shortened where there is no shade. The time of maximum bearing also varies with the different kinds and conditions, but it may be taken to be when the cocoa is from ten to fifteen years old. As regards yield, statistics from various cocoa-growing countries, including Trinidad, Ecuador, Surinam, Nicaragua and Mexico, have shown an annual return of dry cocoa per tree varying from 1 lb. in Trinidad, Ecuador and Nicaragua to 5 to 8 lb. in Mexico (see *Theobroma Cacao or Cocoa*, Wright, 1907, p. 194); it is natural that under the varying conditions different authorities in the same country should

give different figures: in Trinidad the figures vary from 1 lb. to 2 or 3 lb., in Ecuador from 1 lb. to 2 lb. in the case of special trees, and in Mexico from 1½ lb. to the high yield mentioned. Returns of 15 to 30 lb. of specially prolific trees have been known (*Cacao*, Hart, 1911, p. 222); they encourage the opinion that selection in propagation would materially increase the crops of cocoa.

A method of estimating the yield by the return of bags of 165 lb. per thousand trees has been employed in Trinidad (*Bulletin of Agric. Inform., Trinidad*, 1909); the figures given in this way vary from 10 to 15 bags to 25 to 30 bags in more recent returns; this means a crop of 1·7 lb. to nearly 5 lb. per tree, although the latter limit is rarely realised. Regarding the returns per acre, an average of 229 lb. of cured cocoa was found in Ceylon from actual records from a few plantations, extending over six years, the limits being 114 and 1,026 lb. (*Theobroma Cacao or Cocoa*, Wright, 1907, p. 186). The returns from actual records have been made from more extended observations in Surinam (*Proc. Agric. Soc. Trinidad and Tobago*, 1909). They show that during seven years of normal yield the return per acre varied from 304 lb. to 481 lb., with an average of 444 lb., and they are of particular value from the fact that they were taken from observations from all the cocoa estates in Surinam, occupying during the period an area varying from 13,472 acres to 16,305 acres.

The chief care in cocoa picking is to avoid injury to the areas of tissue, called cushions, on the stem and chief branches, which bear the flowers. The stalk of the pods should be severed between the fruit and the ridge or "joint" that is on the stalk. For cutting the pods within reach a sharp knife is best; for those higher up various forms of picker (known as "cocoa hook," "golette," and "podadera" in different countries) are used. These pickers are described, with accounts of their various merits, in works dealing generally with cocoa growing. All knives and pickers used for the work should be made of good steel and kept well sharpened.

The time for picking cocoa is when the pods are just mature; and the work should be carried out, under proper supervision, by gangs who have special experience in the

matter, in order that no doubt may exist as to the proper stage of ripeness of the pods that are picked. Some indication of this stage is given by the fact that, whether they are red or green before they are ripe, they develop a yellow colouring matter when ripening which turns the red to a brighter red or to orange, and the green to a brighter green or to yellow. As the trees bear at the same time fruits in different stages as regards maturity, the work of the picking gangs is arranged so that they go over the same ground frequently at short intervals.

The pods that have been picked are sometimes heaped to remain one or two days before being opened, or are opened as soon as they are left by the picking gangs, or brought to the curing house and broken there. The last plan is the best. The manner of opening the pods varies from the simple striking of them together, on native holdings, to the use of a cutlass (machete) or large knife on plantations where the work is organised; in Central America the fruits are struck sharply on a hard log. In any case, this work, and that of emptying the parts of the broken pods, needs experienced and skilled labour if it is to be done in the most economical manner. The classification of the produce for treatment in separate lots according to the quality of the pods or the seeds is usually regarded as impracticable on plantations; Hart (*Cacao*, 1911, p. 140) suggests that it might be carried out if "central factories" for cocoa curing were inaugurated. In any case, diseased pods should be rejected and put to rot among the husks.

The Fermentation and Drying of Cocoa

The objects of fermenting cocoa are (1) to remove the bitter taste of the fresh bean; (2) to develop the characteristic taste and aroma, and the colour; (3) to make brittle the interior of the bean and to loosen and toughen the skin, for the purposes of manipulation by the cocoa manufacturer; (4) to liberate theobromine, the stimulating principle of cocoa; (5) to cause the bean to fill out and become thicker; and (6) during the fermentation, the pulp covering the seeds is destroyed or reduced to an amount of substance which eventually forms only a very thin skin over the dried actual skin of the seed.

The process of fermentation is conducted in different ways in the various cocoa-growing countries. In a general way it may be described as putting the cocoa seeds, with their pulp, into receptacles so arranged that heat will develop and much of the products of fermentation drain away, and that the cocoa may be easily turned over every day or every other day. Sometimes, as in Ceylon and Java, the cocoa is washed after fermentation; in some other cases, the liquor draining away from the fermenting cocoa is returned to it; and there are other processes, such as polishing and claying the cocoa, which will be dealt with later.

The first action in fermentation is the formation of alcohol and then acetic acid from the sugar in the pulp on the outside of the seed, with a development of heat which kills the cells in the seed leaves, and the germ. The pulp, as such, therefore virtually disappears, and this is an advantage, as its destruction prevents the finished product from being covered with a moisture-absorbing layer which would encourage the growth of moulds and spoil the appearance of the beans. This fermentation takes place in two stages: first the change of sugar to alcohol by the action of yeasts, then the formation of acetic acid from alcohol by oxidation caused by bacteria. Suggestions have been made for the commercial utilisation of the alcohol and vinegar produced; but little has been done for the exploitation of the by-products of the fermentation (see *The Fermentation of Cacao*, edited by H. H. Smith, 1913, pp. xxiv.–xxxv, 216–220, 249–251).

For the formation of alcohol and acetic acid from the sugar in the pulp oxygen is necessary; and this is one of the reasons why the beans are turned over frequently so that they all are given free contact with the air. On the killing of the protoplasm in the interior of the seed, that is in the seed-leaves (cotyledons) and the germ (embryo), ferments are introduced or set free which bring about changes in the interior of the bean, and part of the substances formed from the pulp passes within through the outer covering or skin; one of the effects of the fermentation is to make this passage possible. Opinions differ as to the relative importance of the action of the ferments (enzymes)

set free in the interior of the seed through the death of the cells, and the ferment (zymase) which is formed by the yeasts in the pulp, and enters with the liquid absorbed into the dead seed; it may be that both actions are important. There is certainly evidence for internal fermentation by ferments that are already in the seed, from the fact that changes of the kind caused by ferments will take place in fresh seeds deprived of their pulp and therefore of the conditions in which the yeasts will act. More also remains to be known regarding the effects of the presence of the alcohol and acetic acid that have passed into the interior of the bean.

One of the actions of the enzymes in the beans seems to be a breaking up, with the assistance of water and oxygen, of a glucoside, cacaonin, into (1) the alkaloid theobromine, (2) an inert colouring matter, cacao-red, and (3) a reducing sugar: all authorities are not, however, agreed as to the presence of the cacaonin and the formation of theobromine and cacao-red in this way. It seems, however, correct to conclude that the important stimulating alkaloid theobromine is formed through the action of enzymes, whatever the details of this action may be. Another operation of consequence, that takes place through the presence of enzymes, is the oxidation of the bitter principle of the fresh beans to a tasteless substance. The bitter principle was once thought to be of the nature of a tannin, but it is said that it does not possess some of the characteristic properties of the tannins and has now been given the name of cacaool; when oxidised it yields a coloured substance which some authors regard as identical with cacao-red.

The characteristic taste and aroma of cocoa are due to the presence of an essential oil (*Journ. Chem. Soc.*, 1912, **101**, 2209) which is formed during fermentation. A very small amount of this oil is capable of communicating its odour and taste to a large quantity of absorbent substance. The roasting to which cocoa is subjected during manufacture has the effect of reducing the bitter taste that still remains after fermentation and of increasing the characteristic taste and smell of the cocoa.

The turning brown of the cocoa during fermentation

is probably mostly caused by the formation of cacao-red from cacaool through the action of enzymes in the necessary presence of air; this may not, however, be the sole mode of origin of the brown colour. It has been proved to be formed by the action of enzymes in conditions where living organisms such as yeasts and bacteria have been eliminated; and the colour is deepened by the processes of drying and roasting.

The valuable constituent of the beans called cocoa butter is one of the contents of the fresh seeds, and its amount is altered very little during fermentation, being slightly lessened. It is extracted from the cocoa in the manufacture of cocoa products.

In ordinary fermentation in boxes the temperature reaches about 100° F. in twenty-four hours; in forty-eight hours it has reached about 110° F., and often exceeds this by two or three degrees; where, as in Trinidad, cocoa is allowed to ferment for ten or eleven days, still higher temperatures may be experienced. In a general way the best results are likely to be obtained at temperatures in the neighbourhood of 115° F.; they should never fall below 100° F. There is likely to be serious damage to the cocoa if the beans attain temperatures near 140° F.; the proper moving and turning ("changing") of the beans, however, prevents this. The first rise of temperature has the effect of killing the seed, which cannot survive a temperature of 111° F. for any length of time; the subsequent maintenance of the temperature assists the activity of the enzymes, which is greatest between 112° and 140° F.; the enzymes are destroyed at about 160° F. An effect of fermentation at too high a temperature is the formation of butyric acid through the action of bacteria, and the consequent development of a rancid taste in the cocoa. A knowledge of the best temperatures to be attained during fermentation is a matter of experience.

The time needed for the best fermentation is also a matter of experience. From five to nine days is the time usually taken in practice; small lots of cocoa demand a longer fermentation which is also necessary where the temperature of the air is somewhat lower than is usual. If the process is continued for too long a time, rancidity

arises in the same way as when it is conducted at too high a temperature.

Sprinkling the beans with water or with the liquor from the fermenting mass is not generally advised. Frequent exposure of all the beans to the air, and free drainage from the boxes or tanks, are matters of necessity. Washing after fermenting the cocoa is only done to any extent in a few countries, namely Ceylon, Java (where it is general), and parts of Central America. Usually the loss in weight through washing is not compensated by the increased price for the product; whilst washed cocoa is more difficult to dry than the unwashed, and the process is likely to spoil the finer sorts.

Among the substitutes for fermentation, or modifications of the procedure, that have been suggested or recommended are the following: (1) crushing and drying the beans; (2) soaking the beans in alcohol, subjecting them to alcohol vapour, wetting them with water and then drying them; (3) artificial heating, or freezing, to kill the seeds before fermenting them (Fickendey) (cf. this BULLETIN, 1912, **10**, 239); (4) the use of steam for preparing a product of cocoa; (5) treatment of the fermenting mass with a weak solution of potash (Fickendey), in order to take advantage of the increased activity of enzymes in a neutral or alkaline medium; (6) a short fermentation sufficient to kill the seed, followed by drying to a water content of 15 per cent., and then oxidation by heating in air at 104° F. to 113° F. (Schulte im Hofe); and (7) the use of prepared yeasts in fermentation (Preyer, Nicholls and others). The first three of these have for their object the killing of the seed, previous to its internal fermentation, by artificial means. None of them has reached any importance on a commercial scale.

It is to be remembered that, although careful fermentation is essential for the production of good cocoa, there is no known method that will enable the best sorts of cocoa to be made from the produce of the inferior kinds of trees. Cocoa takes its quality in the first place from the variety of the plant from which the beans come.

The drying of the fermented beans is carried out either by spreading them in the sun or by means of different

forms of artificial driers ; the use of the latter is imperative on plantations producing large quantities of cocoa, when there is likely to be frequent rain during the time of preparing the crop. The chief disadvantages of sun drying are that the process takes a longer time than artificial drying, and that it is generally likely to receive interference through rain. There are compensating advantages, however, where little rain falls during crop time, in that the time needed for sun drying gives opportunity for the complete and uniform action of the enzymes in the whole of the cocoa produced, and that it is less likely to contain a proportion of brittle beans through irregular drying ; sun drying under proper conditions gives a brighter-coloured, more uniform product than artificial drying. Artificial drying must be conducted with care to ensure that there is no overheating, which will quickly destroy the enzymes and give rise to a brittle, dark-coloured product of irregular character. On some plantations in Trinidad a combination of the two methods is employed, closed houses being used for the artificial drying which can be opened for the sunshine to reach the beans when the weather is fine.

For sun drying there must be some means of keeping the cocoa dry when it rains. In Trinidad, sliding roofs which travel over the floors on which the cocoa is spread are used ; in some other countries, such as Grenada, Java and Surinam, the fermented cocoa beans are spread on wooden trays, often one above the other, which are supported on small rollers or wheels, running on rails, so that they may be pushed easily in and out of the drying house ; when they are arranged one above the other any lower pair of rails is longer than the one above by the length of a tray, so that when the trays are fully pulled out they appear in plan one arranged behind another. For proper drying, with as little loss of time as possible, the beans have to be constantly stirred ,so that they may all be well exposed ; this stirring is conducted so as to leave bare for a time successive parts of the floor of the tray, so that they may be dried as well. A form of drying apparatus which is simpler than that just described and is used by small proprietors consists of a set of trays provided with handles at the corners ; these are stacked one above another under

cover, with the cocoa in them, at night or when rain threatens.

The most commonly used machines for artificial drying are the rotary driers, in which the cocoa is dried by hot air while it is in continual movement through being contained in a rotary cylinder ; the principal machines of this kind on the market are the Gordon or Guardiola drier and the Hamel Smith drier. In Trinidad arrangements for drying that cannot be strictly called machines are in common use as well as those ; in one, air is heated by hot-water pipes beneath the floor of an ordinary drying house with a movable roof, so that the process may be combined with sun drying ; in another, which may be used in the same way, air heated by passing over steam pipes is drawn upward by a fan through holes in the floor, while the cocoa is stirred by slanting boards fixed to arms radiating from a revolving shaft (kiln drying). A somewhat similar arrangement to the latter is found in the Huitzer drier, in which, however, the floor is a heated revolving metal plate above which hang stationary rakes whose teeth slowly stir the cocoa as the plate moves beneath them. Other machines are Mayfarth's drier in which the cocoa is dried on perforated trays by air rising through a sloping wooden shaft from a slow-combustion stove, and vacuum machines such as Scott's drier ; the former is more especially suited for use by small owners. In Ceylon and Java the cocoa is mostly dried in special buildings of a simple type, in which hot air from a furnace in a lower storey passes to an upper storey through a floor on which the cocoa is laid. More detailed descriptions of these and the other curing houses described above, as well as of the various forms of drying machines, are to be found in the works dealing generally with the production of cocoa.

In most countries the cocoa receives no further attention than fermenting and drying, except that the opportunity is sometimes taken of discarding broken beans and rubbish during the manipulation attendant upon the latter process. In Trinidad and Venezuela, however, the cocoa is clayed or stained after fermentation ; that is to say, a certain amount of fine earth is incorporated into the wet layer on the outside of the drying beans ; in Trinidad the

process is called dancing, as the incorporation of the earth is assisted by the treading of labourers upon the mass of wet beans upon which the dry earth has been sprinkled. Details of these processes, which require a certain amount of native skill, are given by different authorities on cocoa growing (see especially *Cocoa*, Van Hall, 1914, p. 225; and *A Treatise on Cacao*, Oliveri, 1903, p. 94: passage quoted in the former work, p. 351). Polishing of the cocoa takes place during claying, and is effected to some extent while it is being dried by mechanical means; machines for the special purpose are on the market, and include Barnard's patent cacao polisher and the Malins-Smith cacao-polishing machine.

Regarding grading, if this is done it takes place on the drying floors, especially on those of local cocoa-buying merchants; mechanical grading is also employed, by means of an apparatus consisting of cylindrical sieves of different mesh arranged to form one long cylinder rotating on a slightly inclined axis; rubbish and poor beans are separated at the upper end, cocoa of medium grade in the middle and the beans of best quality at the lower end (see *Cacao*, Hart, 1911, p. 177).

The percentage loss in weight that takes place during fermentation and drying has been found by experimentation in different places, and the following results among others have been obtained: Trinidad 62, Dominica 58, St. Lucia 63 and 67, Surinam 66 and 68, Madagascar 60. This means that the quantity of dry cocoa obtained may be expected to be from 32 to 42 per cent. of the weight of the fresh beans, depending chiefly on the material and conditions of the fermentation and the proportion of water left in the dried beans. The washing of the cocoa results in a further loss of 4 to 7 per cent.

Pests and Diseases of Cocoa

Insect Pests

For convenience these pests may be classified into insects that remain outside the tissues they attack—external feeders, and those that enter the parts of the plant where they are found—internal feeders. The

external feeders may in turn be regarded separately as biting insects and sucking insects, and the internal feeders as borer beetles and borer caterpillars; all these internal feeders are of course biting insects. In this way the different insects attacking cocoa are regarded in the light of the damage that they do and the methods adopted for control.

Generally speaking, the external biting insects are best combated by applying an arsenical poison, such as Paris green, to the plant, either as a spray or in the dry form. In the former case 1 lb. of Paris green and 2 lb. of freshly slaked lime should be mixed with 150 to 200 gallons of water, and when applied as a powder 1 lb. of Paris green should be mixed with 5 or 6 lb. of dry air-slaked lime. In either case, the insecticide should be evenly distributed over all parts likely to be attacked by the insect. Occasionally, as in the case of the mole cricket, such pests may be kept under control by the use of poisoned bait consisting of bran, grass or dung, treated with white arsenic. Sucking insects are usually soft-bodied and as a rule may be successfully dealt with by spraying with kerosene emulsion or with a wash containing one or more of the following: whale-oil soap, soft soap, rosin and tobacco; these substances act either as poisons, entering the body through the breathing pores (or spiracles), or they cause suffocation by closing up the latter. The Helopeltis bugs, however, appear to be little affected by ordinary sprays, and the usual method of procedure is to catch the insects by means of sticky nets or bamboos bearing cobwebs at one end. The boring insects are, on the whole, more difficult to deal with, owing to their position within the tissues of the plant. The best plan is to cut out and burn the affected part, where this is possible, and treat the wound with tar. The insertion of a flexible wire into the hole from which a boring larva ejects its frass is very effective in dealing with such insects. Much may be done to keep these insects down by removing all dead branches from the trees and from the ground, as these often serve to harbour the pests, whilst in certain instances branches of other trees, which are more favoured by the pest than the cocoa is, may be placed on the ground to act as traps in which the eggs are

laid, such branches being removed and burned at intervals of a few days.

The table on pages 70, 71 gives a list of the chief known insect enemies of cocoa, the names being followed by information as to the chief countries where they are known to occur, and the general methods of control; the most serious pests in the various countries are indicated by an asterisk. In addition, reference may be made to the chocolate moth (*Ephestia elutella*), the larva of which attacks stored cocoa in Ceylon, the West Indies and Java. It may be kept in check by a thorough cleaning and white-washing of the stores when emptied of cocoa and by fumigating the empty store with carbon bisulphide.

Other Animal Pests

The most persistent general pests of cocoa, besides insects, are rats and squirrels, which are reported to be specially injurious in the West Indies, Ceylon, West Africa, Java and Samoa; they gnaw away part of the pods hanging on the trees and eat the seeds, scattering more than they devour; the damage that they do in this way is sometimes so extensive that the wasted seeds are collected and sold as "rat cocoa" or "black cocoa." These pests are encouraged in neglected cultivation, particularly where the plantations are near forest or other untouched land. Of the two pests, rats cause by far the more loss; they are best controlled by laying down poisoned food; the squirrels by shooting them. Larger rodents and other animals, such as pigs and deer, are likely to do damage from time to time in some countries, especially in Trinidad, Java, West Africa and Surinam; there is most danger from them where the cocoa is grown near wild country; several of them are kept in partial control by being hunted and shot for their flesh. Cocoa trees in South and Central America are likely to suffer severely from bands of monkeys; the gun, again, affords some means of control for these; but wherever it has to be used in or near cocoa plantations, care is needed for avoiding injury to the trees in the form of wounds that may admit the attacks of fungi causing disease. Birds, so injurious to very many fruits, do not seem ever to do any grave damage to cocoa.

INSECT PESTS OF COCOA

Name of insect.	Countries where prevalent.	Part attacked.	Preventive and remedial measures.
EXTERNAL FEEDERS			
Biting Insects			
Mole cricket (*Scapteriscus didactylus*)	W. Indies and S. America	Stems of very young plants	Spraying with Paris green or use of poisoned baits
Red spider (mites) (*Erythraeus telarius*, etc.)	Widely distributed	Leaves and fruits	Spraying with water or soap solution
Leaf-cutting beetles (Species of Carabidæ and Cassidæ)	W. Indies and S. America	Leaves	Dusting with Paris green and lime or spraying with Paris green or lead chromate
*Adoretus leaf-beetle (*Adoretus hirtellus*)	Nigeria	Do.	Do. do.
Leaf caterpillars:			
Orthocraspeda trima	Java	Do.	Do. do.
Belippa lohor	Java	Do.	Do. do.
Parasa lepida	Java and Ceylon	Do.	Do. do.
Diacrisia maculosa	Nigeria	Do.	Do. do.
Prodenia litura	Nigeria	Do.	Do. do.
Surinam leaf caterpillar	Surinam	Do.	Do. do.
*Parasol ant (*Oecodoma* spp.)	Trinidad and S. America	Do.	Fumigation of nests with carbon bisulphide and isolation of infected area by a trench filled with water
Brand mier of Surinam (a species of ant)	Surinam	Do.	Do. do.
Twig girdlers of sawyer beetles (*Endesmus grisescens* and *Ecthoea quadricornis*)	West Indies	Branches	Removal and burning of all dead wood and capture of mature insect
Basket worm (*Metisa sierricola*)	Nigeria	Do.	Do. do.
Sucking Insects			
Podhoppers (*Horiola* sp.)	West Indies	Fruits	Spraying with kerosene emulsion or whale-oil soap, soft soap, rosin or tobacco washes
*Thrips (*Physopus* spp., etc.)	West Indies and Surinam	Leaves and fruits	Do. do.
Plant lice (green, red or black fly) (*Aphis* spp.)	Widely distributed	Young vegetative parts, flowers and fruit stalks	Do. do.
*Stem sapper (*Sahlbergella theobroma*)	Gold Coast	Twigs, leaf-stalks and fruits	Do. do.
*Stem sapper (*Sahlbergella singularis*)	Cold Coast, Nigeria, Congo	Do. do.	Do. do.
Scale insects and white fly (species of *Lecanium*, *Aspidiotus*, *Dactylopius*, *Aleurodes*, *Stictococcus*, etc.)	Widely distributed	Do. do.	Do. do.
*Helopeltis bugs (*Helopeltis antonii* and *H. theivora*)	Ceylon and Java	Twigs and fruits	Catching the insects

INSECT PESTS OF COCOA (*continued*)

Name of insect.	Countries where prevalent.	Part attacked.	Preventive and remedial measures.
EXTERNAL FEEDERS (*continued*)			
Sucking Insects			
*Helopeltis bugs (*H. schoutedeni*) . .	Congo	Twigs and fruits	Catching the insects
*Helopeltis bugs (*Helopeltis* sp. allied to *schoutedeni*)	Gold Coast	Do. do.	Do. do.
*Mosquilla (allied to *Helopeltis*) . .	Ecuador	Do. do.	Do. do.
Fruit fly (*Ceratitis nigra*) . . .	Nigeria	Fruits	
INTERNAL FEEDERS			
Borer Beetles			
*West Indian borer beetle (*Steirostoma depressum*)	W. Indies and S. America	Stems and branches	Excision of the larvæ and use of "trap" wood
*West Indian borer beetle (*S. histrionica*)	Trinidad	Do.	Do. do.
Trachyderus beetle (*Trachyderus succinctus*)	West Indies	Do.	Do. do.
*Glenea borer (*Glenea novemguttata*) .	Java	Do.	Do. do.
*Glenea borer (*Glenea* sp) . . .	Gold Coast	Do.	Do. do.
Armatostema borer (*Armatostema buquetiana*)	Gold Coast	Do.	Do. do.
Catoxantha beetle (*Catoxantha bicolor*) .	Java	Do	Do. do.
Pinhole borers (*Xyleborus perforans* and *Tomicus* sp.).	West Indies	Do. (particularly of weakly plants)	Good cultivation
Pelargoderus beetle (*Pelargoderus bipunctatus*)	Java	Stems and branches	No organised remedial measures
Java Monohammus beetle (*Monohammus fistulator*)	Java	Do.	Do. do.
Cameroons Monohammus beetle (*M. ruspator*)	Cameroons	Do.	Do. do.
Root borer (*Diaprepes abbreviatus*) . .	Trinidad	Roots	Catching the beetles
Caterpillar Borers			
Java Zeuzera borer (*Zeuzera coffeae*) .	Java	Stems and branches	Burning of all dead branches and removal of larvæ from live wood by means of a stiff wire
African Zeuzera borer (*Zeuzera* sp.) .	San Thomé and Cameroons	Do.	Do. do.
Eulophonotus myrmeleon . . .	Nigeria	Branches	Do. do.
Cocoa pod moth	Nigeria	Fruits	Burning all rotten and useless pods
*Cocoa moth (*Zaratha cramerella*) . .	Java	Do.	Picking and burning yearly all fruits not in the main crop
Leaf and pod miners (species of moths)	West Indies	Leaves and fruits	Picking affected leaves and pods

FUNGOID DISEASES OF COCOA

Name of disease.	Name of fungus.	Countries where prevalent.	Preventive and remedial measures.
Brown root disease	*Hymenochaete noxia*	Ceylon, West Africa, Samoa and New Guinea	Removal of all dead stumps, drainage, isolation of infected area by a trench and treatment of soil within the area with lime
White root disease	*Fomes semitostus*	Ceylon, Java and Malaya	
White root disease	*Polyporus lignosus*	Nigeria	
White root disease	Unidentified	West Indies	
Black root disease	Do.	Do.	
Root disease	Do.	Do.	
Do.	Do.	Ceylon	
Do.	Do.	Cameroons	
Stem disease	*Melanconium theobromae*	Nigeria	
Stem canker	*Phytophthora Faberi*	Widely distributed	Reduction of shade, drainage, burial or burning of all diseased pods, spraying with Bordeaux mixture, and, in the case of canker, burning of all diseased branches and excision of diseased parts of stems, with subsequent tarring of wounds
Black and brown rot of pods			
Chupon wilt			
Die-back	*Diplodia cacaoicola*	Widely distributed	Provision of proper shelter and shade; thorough pruning of affected trees and destruction of dead branches and decaying pods
Djamoer oepas	*Corticium javanicum*	Java and Ceylon	Reduction of shade, destruction of diseased branches and spraying with Bordeaux mixture
Pink disease	*Corticium salmonicolor*	Nigeria	
Do.	*Corticium lilacino-fusaini*	St. Lucia, Dominica	
Do.	*Stilbospora cacao*	Trinidad	
Horsehair blight	*Marasmius equicrinis*	Trinidad, Grenada, St. Lucia, Gold Coast (?)	
Thread blight	*Marasmius scandens*	Gold Coast	Scrape off with a wooden-bladed knife and spray with Bordeaux mixture
Wet canker	*Nectria theobroma*	Gold Coast	
Surinam witch-broom	*Colletotrichum luxificum*	Surinam and British Guiana	Pruning and destruction of affected parts and spraying with fungicides
Anthracnose	*Colletotrichum* sp.	Nigeria	
Cameroons witch-broom	*Taphrina Bussei* (?)	Cameroons	
Thread-blight or cobweb fungus	*Stilbella nana* (?)	West Indies, Ceylon, Java and Cameroons	

Fungoid Diseases

The best preventive of disease is good cultivation, and several of the precautions and remedies needed for obtaining healthy plants are included in this. Good cultivation cannot, however, be always depended upon alone for the protection of plantations from disease, especially in abnormal seasons of wetness or dryness, or when the normal balance is upset in any other way ; so that special remedies are often necessary, even in the best-kept plantations. The names of the chief diseases and of the fungi that are considered to cause them, the countries where they are mainly found and their most general methods of prevention and remedy, are shown on the preceding page.

COTTON GROWING IN MESOPOTAMIA

MESOPOTAMIA, which may be roughly described as the country lying between the Euphrates and Tigris, covers about 50,000 square miles of sandy but fertile soil. The climate varies from extreme heat in summer to a degree of cold in winter comparatively rare in corresponding latitudes. The temperature is highest in July and August, when it ranges approximately between 78° and 115° F. with a mean of about 90–100° F., and is lowest in December and January, when it varies roughly between 37° and 62° F. with a mean of about 47° to 55° F.

In July 1909 a maximum temperature of 119·8° was reached, and in January 1911, when the weather was exceptionally cold, a minimum of 25° was recorded. The rainfall is not sufficient for the requirements of agriculture, and irrigation must therefore be practised. The mean annual precipitation amounts to only about 10 inches, but considerable variation occurs, the rainfall in 1894, for example, being as much as 22 inches, whereas in 1901 it was only 1·6 inches. The typical soil of Mesopotamia is a light calcareous loam which contains about the same amount of nitrogen as the average soils of Egypt and sufficient potash and phosphoric acid to maintain the growth of the cotton crop without the application of manures. The inhabitants of the country are chiefly

Arabs and Kurds, who are more or less nomadic in their habits.

The region between the Tigris and Euphrates is liable to inundation from both rivers when in flood. The rivers pursue a devious course through a wide plain and have many tributaries and cross connections. In certain areas they spread out into vast marshes. When in flood the rivers carry about five times as much silt as the Nile, and this adds greatly to the cost of canal irrigation. From Bagdad to the sea-coast, the Tigris has a slope of 1/130,000, and has deposited its coarser mud within the first 150 miles. This has rendered the upper reaches of the river exceptionally fertile, owing to the friable nature of the soil. At about 50 miles below Bagdad the deposits begin to become finer and salted, and this continues to the sea. The latter soils are sometimes too salt for agriculture, and are much inferior to the friable deposits to the north and south of Bagdad, which are eminently adapted for cultivation under irrigation. The salt lands should, however, be easily reclaimable, provided that a sufficient supply of water is available.

Cotton has been grown in Mesopotamia to some extent from very ancient times, and is now cultivated by the Arabs in small quantities along the banks of both the Tigris and Euphrates. The crop is used locally for spinning, and as a stuffing material for pillows and mattresses, etc. The plants are usually grown in conjunction with food crops. The native cotton, which is apparently derived from an indigenous type of *Gossypium herbaceum*, is of variable quality, but on the average approaches the "middling" American grade. Attempts have been made from time to time to grow Egyptian varieties, and small quantities of these cottons are now cultivated at Amara, Basra and other places. On the banks of the Diala, another variety is grown which resembles the Indian types of *G. herbaceum* and has a length of staple of about $\frac{7}{8}$ in. The valves of the boll of this variety curl inwards when the boll opens, and this renders the picking particularly laborious, and in consequence the cotton is generally leafy and dirty.

In general, Mesopotamia possesses a soil and climate

favourable to the production of large yields of excellent cotton. The development of the industry is at present restricted, however, by the smallness of the population and the need for irrigation and drainage. It is also necessary that transport facilities should be improved, agricultural machinery introduced, and instruction given to the natives in the methods of cultivating and harvesting the crop.

In 1917 it was decided that an enquiry should be made into the economic and commercial potentialities of Mesopotamia, and Messrs. Holland and Wilson, who were appointed Joint Trade Commissioners for this purpose, reported that the climatic and soil conditions were well adapted for cotton growing, and recommended that an expert from India should be deputed to carry out tests on experimental plots with a number of different varieties of cotton. As a result of this recommendation, Captain R. Thomas, B.Sc., of the Indian Agricultural Service, was appointed towards the end of 1917 as Cotton Expert for Mesopotamia.

On arriving in Mesopotamia, Captain Thomas first took steps to select a suitable site for experiments in 1918. With this object in view, he made a rapid tour to the lower reaches of the Shatt-el-Arab from Basra to Mohammerah; the Tigris, in the neighbourhood of Amara and Bagdad; and the Euphrates, in the vicinity of Nasiriyah and Hilla. It was found that cotton was already being grown to some extent at all those centres of general cultivation on the banks of the rivers where there is a perennial water supply, but that the production was insufficient to meet the local demand.

A site for the first cotton experiment station was eventually chosen at Karradah, on the outskirts of Bagdad. An account of the methods of cultivation adopted in 1918 and the results of the experiments is given by Captain Thomas in his *Interim Report on Cotton Experimental Work in Mesopotamia in* 1918 (Bagdad: Government Press, 1918).

It was originally intended to plant a complete series of plots at intervals of a few days, beginning in the second week of March, but by the end of the first week of March

the only seed which had arrived was that ordered from Madras and Sind. The supply from the Punjab arrived on April 10, whilst the Egyptian seed was not received until the middle of May. The following varieties were sown:

Cambodia.—This cotton is of American origin, and has been largely cultivated in Cambodia, Indo-China. Of late years it has been grown in increasing quantities in India (compare this BULLETIN, 1919, **17**, 392, 585). It has an average length of staple of about 1 in.

4 *F.*—This is an Indian cotton which was originally obtained by selection by the Economic Botanist at Lyallpur in the Punjab (compare this BULLETIN, 1919, **17**, 371). Three other Punjab types, viz. 280 F, 285 F and 286 F, were also tested; these have a staple length of just over 1 in.

Webber 49 is a unit strain selection recently brought from the United States by the Principal of the Lyallpur Agricultural College, and has an average length of staple of $1\frac{3}{8}$ in.

Black Rattler, *Triumph* and *Allen's Long Staple* are well-known American Upland varieties, which have been grown experimentally in Sind.

Chanda is a variety grown in the Central Provinces, India. Seed of this cotton was introduced into Mesopotamia in 1917 by the Assistant Director of Agriculture, Amara, and was sown at Sheik Sa'ad.

Sakellaridis, *Afifi* and *Ashmouni* are well-known Egyptian varieties, the seed of which was procured from Egypt.

Basra is the name given to a mixture of Egyptian and American cotton grown near Basra, which has a staple of $\frac{7}{8}$–$1\frac{3}{8}$ in. A small plot was planted with seed obtained by bulk selection from the 1917 crop, whilst another plot was sown with unselected seed; the object of these plantings was to secure material for unit strain selection.

Turkish is the term applied to the seed of an Egyptian variety which is alleged to have been left in Mesopotamia by the Turkish Government.

Tinnevellies D is a unit strain of *Gossypium obtusifolium* isolated from commercial Tinnevellies; it has a length of staple of $1\frac{1}{4}$ in.

The trials had to be carried out under conditions which rendered it impossible to treat the crop as originally intended, but the experience gained was sufficient to show that the Bagdad farm was well suited in respect of both soil and climate to the cultivation of American and Egyptian cotton. It was also found that, owing to the exceptionally high temperatures which prevail in the summer months, the water requirements in Mesopotamia will be greater than those of Egypt. Excellent results were obtained with Webber 49, a cotton which showed a remarkable combination of good characters, whilst the following varieties were regarded as unsuitable for further experiments: Chanda, 280 F, 286 F, Cambodia, Basra and Tinnevellies D. Another conclusion drawn from these trials is that in order to obtain the best results the cotton should be planted if possible before the end of March, and in no case later than the middle of April. It was also found that the local conditions are well adapted to the cultivation of berseem (Egyptian clover), a crop which in Egypt commonly precedes cotton. The cotton stalks are readily saleable in Mesopotamia for use as fuel.

Samples of the various cottons grown in these trials in 1918 have been received through the Indian Trade Commissioner in London, and the British Cotton Growing Association, and have been examined at the Imperial Institute and valued in Liverpool. The results are given below.

No. 1. *Cambodia.*—Fairly soft, lustrous, deep cream-coloured cotton, with occasional stains. The sample was rather darker than, but otherwise similar to, a sample of Cambodia cotton from India examined at the Imperial Institute in 1916 (cf. this BULLETIN, 1917, **15**, 162). The cotton was of fairly good strength. It was mostly from 0·9 in. to 1·1 in. in length, with an average of 1·0 in.

The sample was of good middling grade, and was valued at 30·50*d.* per lb. (March 1920) with American cotton (March futures) at 27*d.* per lb.

No. 2. *Punjab* 4 *F.*—Slightly harsh, lustrous, creamy white cotton, with occasional brownish stains, and a small amount of leaf. It was of fairly good strength and ranged

in length from 0·5 in. to 1·3 in., being mostly from 0·8 in. to 1·0 in.

The sample was valued at 17·50*d.* per lb. with good middling American cotton at 20·24*d.* per lb. (August 1919).

This cotton was very similar to samples of 4 F cotton received at the Imperial Institute from the Punjab.

No. 3. *Punjab* 280 *F.*—Pale cream, soft, lustrous cotton, of American Upland type. It was of good strength, and was mostly from 0·9 in. to 1·2 in. in length, with an average of 1·0 in.

The sample was of about good middling grade, and was valued at 35·00*d.* per lb. (March 1920) with American cotton (March futures) at 27*d.* per lb.

No. 4. *Punjab* 285 *F.*—Very pale cream-coloured, soft and silky, lustrous cotton. The strength was fairly good, but somewhat irregular. The length ranged from 0·7 in. to 1·4 in. and was mostly from 1·1 in. to 1·2 in.

The sample was of fully good middling grade, and was valued at 22·50*d.* per lb. with good middling American cotton at 20·24*d.* per lb. (August 1919).

No. 5. *Punjab* 286 *F.*—Fairly clean, soft, silky, lustrous, pale cream cotton, of American Upland type. It was of good strength, and was mostly from 1·0 in. to 1·4 in. in length, with an average of 1·2 in.

The sample was of about good middling grade, and was valued at 34·00*d.* per lb. (March 1920) with American cotton (March futures) at 27*d.* per lb.

No. 6. *Webber.*—Very pale cream-coloured, lustrous cotton, with a small amount of immature fibre and a little broken leaf. The cotton was similar in colour to the samples of Allen's Long Staple (see p. 79) and 285 F (see above). The strength of the cotton was very good, and the length ranged from 0·8 in. to 1·5 in. with an average of 1·2 in.

The sample was of about strict good middling grade, and was valued at 27·50*d.* per lb. with good middling American cotton at 20·24*d.* per lb. (August 1919).

No. 7. *Black Rattler.*—Fairly soft and lustrous, cream-coloured cotton, with occasional slight, pale-brown stains. It was of fairly good strength, and varied in length from 0·8 in. to 1·4 in., being mostly 1·1 in.

The sample was valued at 23·00*d.* per lb. with good middling American cotton at 20·24*d.* per lb. (August 1919).

This cotton was not of such a good colour as a sample of this variety received at the Imperial Institute from Sind, and was slightly shorter in staple, but it had a better lustre (cf. this BULLETIN, 1911, **9**, 227).

No. 8. *Triumph.*—Soft, fairly lustrous, cream-coloured cotton, with a slight amount of dirt and broken leaf, and a little immature fibre. The strength was good and the length varied from 0·5 in. to 1·3 in. with an average of 1·1 in.

The sample was of strict good middling grade, and was valued at 23·00*d.* per lb. with good middling American cotton at 20·24*d.* per lb. (August 1919).

This cotton was stronger and softer than a sample of Triumph cotton from Sind examined at the Imperial Institute, but was slightly darker in colour (cf. this BULLETIN, 1911, **9**, 225).

No. 9. *Allen's Long Staple.*—Very soft, silky, lustrous, nearly white cotton. It was of fairly good strength and ranged in length from 0·8 in. to 1·5 in. with an average of 1·2 in.

The sample was valued at 27·50*d.* per lb. with good middling American cotton at 20·24*d.* per lb. (August 1919).

The cotton was slightly softer, but shorter, than a sample of Allen's Long Staple from Sind, examined at the Imperial Institute (cf. this BULLETIN, 1911, **9**, 226).

No. 10. *Chanda.*—Soft, pale cream-coloured cotton, of good lustre. The strength was fair, but somewhat irregular. The cotton was mostly from 0·9 in. to 1·2 in. in length, with an average of 1·0 in.

The sample was of fully good middling grade, and was valued at 37·00*d.* per lb. (March 1920) with American cotton (March futures) at 27*d.* per lb.

No. 11. *Sakellaridis.*—Soft and silky, lustrous, deep cream-coloured cotton, containing a little broken leaf. It was of good strength and varied in length from 1·0 in. to 2·0 in., being mostly from 1·2 in. to 1·5 in.

The sample was valued at 32·50*d.* per lb. with good Sakel cotton at 32·50*d.* per lb. (August 1919).

No. 12. *Afifi.*—Fairly soft and lustrous, brown Egyptian cotton of somewhat irregular colour. The sample contained a fair quantity of immature cotton together with a small amount of leaf. It was of good strength and varied in length from 0·7 in. to 1·5 in., being mostly from 1·1 in. to 1·3 in.

The sample was valued at 31·00*d.* per lb. with good brown Egyptian cotton at 29·50*d.* per lb. (August 1919).

No. 13. *Ashmouni.*—Fairly clean and soft, rather woolly Egyptian cotton, with a moderate lustre and an irregular pale-brown colour. A small amount of immature fibre was present. It was of good strength, and the length varied from 0·8 in. to 1·5 in., being mostly from 1·1 in. to 1·2 in.

The sample was of good grade, and of character intermediate between Upper Egyptian and brown Egyptian cotton; it was valued at 29·00*d.* per lb. with good Upper Egyptian cotton at 28·00 per lb. (August 1919).

No. 14. *Basra.*—Fairly soft, cream-coloured, lustrous cotton, badly stained in parts. The strength was irregular, but on the whole very good. The cotton was mostly from 0·8 in. to 1·1 in. in length, with an average of 1·0 in.

The sample was of barely good middling grade, and was valued at 33·00*d.* per lb. (March 1920) with American cotton (March futures) at 27*d.* per lb.

No. 15. *Turkish.*—Fairly soft, pale brown, lustrous cotton, similar to Afifi cotton. The sample contained a small amount of leaf. It was of good strength, and varied in length from 0·5 in. to 1·7 in., being mostly from 1·0 in. to 1·2 in.

The sample was valued at 30·00*d.* per lb. with good brown Egyptian cotton at 29·50*d.* per lb. (August 1919).

No. 16. *Tinnevelly D.*—Fairly soft, cream-coloured, lustrous cotton, of good strength. It was mostly from 0·7 in. to 0·9 in. in length with an average of 0·8 in.

The sample was of fully good middling grade, and was valued at 33·00*d.* per lb. (March 1920) with American cotton (March futures) at 27*d.* per lb.

In 1919, experiments were undertaken on six farms in different parts of Mesopotamia with the varieties which

had proved the most promising in the earlier trials. These experiments, however, were hampered by the lack of funds, the inadequacy of the subordinate agricultural staff, and the saline nature of the soil on most of the farms.

During the present year efforts are being made to establish a number of seed-farms with a view to obtaining a supply of seed sufficient to start the cultivation on commercial lines in 1921. Towards the end of 1919, a deputation of the British Cotton Growing Association visited Mesopotamia, and discussed with the Civil Commissioner the terms of an agreement under which the Association will establish a number of model plantations as large-scale demonstration and seed farms. The members of the deputation were very favourably impressed with the possibilities of the country for cotton production. It is understood that although no definite agreement has yet been entered into with the Government, the British Cotton Growing Association have already despatched ginning plant for treating the cotton produced on the area of 200 acres which is now devoted to the crop.

The area which will eventually be planted with cotton in Mesopotamia will depend on the quantity of labour available and the area on which a perennial supply of water can be guaranteed.

With regard to the labour supply, it is estimated that the population between Bagdad and Basra is about 1,500,000, of whom 350,000 are town dwellers, leaving 1,150,000 as the total number of Arab cultivators, including wandering tribes.

With reference to the area with a suitable supply of water, it is estimated that there are at present about 300,000 acres on the banks of the Tigris and Euphrates, which could be irrigated from the rivers themselves by means of mechanical appliances. There are also about 80,000 acres capable of canal irrigation for summer crops on the banks of the Diala river, above Bagdad, and about 120,000 acres on the Euphrates commanded by the Hindia barrage. Assuming that cotton will be grown in rotation with other crops, and that only one-third of the summer irrigated area would be planted with cotton in any one

year, there is a total of 150,000—200,000 acres which could be cultivated annually by the existing population if the necessary facilities were provided.

THE IRON ORES OF SOUTH AFRICA

When *The Iron Ore Resources of the World* was published in 1910, G. A. F. Molengraaff described the more important deposits of iron ore in the Transvaal. The metamorphosed sedimentary deposits of the Swaziland System, Lower Witwatersrand System, and Lower Pretoria Series were stated to contain large quantities of highly siliceous magnetite and hæmatite, which could not be worked with profit under the conditions then prevailing, and were unlikely to be of importance in the future. On the other hand, Molengraaff regarded the magnetite deposits of the Timeball Range quartzite (Pretoria Series), the titaniferous magnetite of the Bushveld igneous complex, and the hæmatite in the Highveld Series of the Karroo System as more promising deposits for economic working.

The last few years have seen the establishment of iron and steel works in the Transvaal. In 1913 the Union Steel Corporation began work at Vereeniging, followed by the Dunswart Iron and Steel Works and the Witwatersrand Co-operative Smelting Works. All these work on scrap metal from the railways and mines. It was not till 1918 that pig iron was produced from ore, when satisfactory results were obtained on a small scale in blast furnaces erected by the Pretoria Iron Mines Limited, near Pretoria, and the Transvaal Blast Furnace Company at Vereeniging. There now seems to be a good prospect of the establishment of a large and profitable iron industry in South Africa, and in the present article an account is given of some of the available deposits of iron ore.

TRANSVAAL

Pretoria District.—In a report received from the Department of Mines on the iron ores of the Pretoria Town Lands, the iron ore horizons in the Transvaal System in the neigh-

bourhood of Pretoria are tabulated in ascending order as follows:

(1) The uppermost beds of the Dolomite Formation.

(2) The Timeball Hill zone of the Pretoria Series.

(3) The so-called "clay-band," a little above the uppermost quartzite bed of the Timeball Hill horizon.

(4) The shales and associated rocks immediately underlying the Daspoort quartzite zone of the Pretoria series.

1. The lowest of these horizons, that in the Dolomite Formation, is represented by impure earthy manganiferous ironstone near Ashbury Siding. The deposit reaches a thickness of 15 feet in places, but is not a workable ore, as the following analysis shows:

		Per cent.
Ferric oxide	Fe_2O_3	20·0
Manganese dioxide	MnO_2	2·2
Alumina	Al_2O_3	2·0
Magnesia	MgO	3·0
Silica	SiO_2	64·9
Moisture	H_2O	7·4
		99·5

2. In the Timeball Hill zone are two main ferruginous beds, which crop out in the hills immediately south of Pretoria. They are generally referred to as magnetic quartzite, but this is a misleading name, the material being in reality an arenaceous oolitic ironstone, fine-grained, hard, and reddish black in colour. The quartz-grains vary in quantity, often giving rise to bands of siliceous material. The oolitic grains consist largely of martite (hæmatite with the form of magnetite), with octahedra of martite, flakes of chlorite, and a hard iron-oxide cement occupying the interstices. The beds are interstratified with the Timeball Hill quartzites and shales; the upper one averages 12 feet in thickness and the lower about 4 feet. The dip is to the north at an angle of about 35°, and faulting has duplicated the beds over a considerable distance, so that the amount of ore available is very large.

The iron content varies between 40·5 and 53·6 per cent. A series of samples taken along the outcrop of the upper bed on Muckleneuk Hill showed 48·6 to 53·6 per cent. of iron, while one from the lower bed at the same locality

contained 51·4 per cent. Two samples from the upper bed gave the following results on analysis :

		Per cent.	Per cent.
Ferric oxide	Fe_2O_3[1]	69·43	65·57
Alumina	Al_2O_3	7·38	6·54
Lime	CaO	0·75	1·20
Magnesia	MgO	0·47	0·44
Silica	SiO_2	17·44	21·96
Phosphoric anhydride	P_2O_5[2]	0·39	0·55
Titanium dioxide	TiO_2	trace	trace
Loss on ignition[3]		4·30	3·70
		100·16	99·96
[1] *Equivalent to iron (Fe)*		48·6	45·9
[2] *Equivalent to phosphorus (P)*		0·17	0·24
[3] *Containing sulphur (S)*		0·014	0·014

Much of the ore could be quarried in open cuts and loaded into trucks at an estimated cost of 3*s*. 6*d*. per ton, while still more could be obtained by adits at a cost of about 6*s*. per ton.

3. The " clay-band " iron ore is of better quality than that in the Timeball Hill zone, but its thickness is much smaller and its outcrop is less persistent. It is a band of hard argillaceous ironstone interbedded with the shales overlying the Timeball Hill zone, and occurs to the south and west of Pretoria. A trial pit was sunk at the exposure near the forester's cottage to the south-east of the Groenkloof Plantation, and the thickness was found to be 2 ft. 4 in. with a dip of 10°. The material is a very fine-grained reddish-brown rock, much jointed, and containing some quartz veins. Three samples from this locality were found to contain 52·5, 51·5 and 46·5 per cent. of iron, respectively. One of them gave the following results on analysis :

		Per cent.
Ferric oxide	Fe_2O_3	73·57[1]
Alumina	Al_2O_3	7·94
Lime	CaO	0·45
Magnesia	MgO	0·33
Silica	SiO_2	7·70
Phosphoric anhydride	P_2O_5	1·19[2]
Loss on ignition		8·60[3]
		99·78
[1] *Equivalent to iron (Fe)*		51·5
[2] *Equivalent to phosphorus (P)*		0·52
[3] *Containing sulphur (S)*		0·029

In spite of the thinness of the band, it is considered worthy of exploitation. There is a fair amount of ore actually at the surface, or easily obtainable by stripping the overburden by means of a steam shovel, while, where the bed lies deeper, the underground mining costs should not exceed 10*s*. per ton. The value of the ore is increased by the fact that, if it is smelted with the siliceous ores, the amount of limestone required to flux the latter is considerably reduced.

4. Interbedded with the shales underlying the Daspoort quartzite there are two persistent bands of ironstone. They are well developed on the southern slopes of Struben Kop, where they are separated by about 100 feet of shale. The upper bed is a ferruginous shale, 2 ft. 6 in. thick, with only 22 per cent. of iron. The lower bed is made up of oolitic or pisolitic grains of hæmatite in a ferruginous sandy matrix. Its thickness is about 3 ft., and its iron content 33·5 per cent. It does not appear that either of these bands is worth working anywhere in the vicinity of Pretoria.

In a preliminary report, dated July 23, 1919, on the lease of the Pretoria Iron Mines Ltd., P. A. Wagner states that the lease is made up of five areas. The three areas included in the original Delfos Lease, and the larger of the two areas acquired from the Lokale Industrieele Syndikaat, form a block of ground lying to the north of the existing blast furnace plant. The remaining area is the Muckleneuk Valley clayband lease. The five areas are referred to as A, B, C, D and E.

Area A adjoins the Pretoria Mental Hospital and includes the western end of the Timeball Hill Range. The siliceous ironstone, or " magnetic quartzite " as it is usually called, is exposed along the crest and dip-slope of the range. Sixteen representative samples taken at regular intervals along the strike of the bed showed an iron content between 45·9 and 53·1 per cent., with silica ranging from 15·75 to 25·59 per cent. The area is estimated to contain 1,900,000 tons of ore, averaging between 45 and 50 per cent. of iron, of which 480,000 tons can be quarried and the remainder won by adit mining.

Area B lies to the north of A and contains a faulted continuation of the "magnetic quartzite" exposed in A. This crops out for a distance of 1,400 yards along the crest of the hills, stretching northward down the dip slope with an outcrop width exceeding 150 yards in places. The bed is duplicated by faulting for a length of 350 yards. The main portion is estimated to contain 6,600,000 tons of ore, of which 1,400,000 tons is suited to open-cast mining, 3,200,000 tons can be recovered by adit mining, and some 2,000,000 tons are said to "fall within the limits of underground mining" (presumably by shafts). In the faulted portion some 75,000 tons can be quarried, and 225,000 tons won by adit mining.

Area C, to the south-west of the Police Camp, contains a large tonnage of ore, most of which is siliceous, but with some clayband ore in addition. The siliceous ironstone forms a continuation of that in Area B, and its tonnage is estimated at fully 19,000,000, of which about 9,000,000 tons can be won by open-cast and adit mining. Twenty-six representative samples taken at regular intervals along the outcrop of the bed in this area showed that the iron content ranges from 41·90 to 51·30 per cent., and the silica from 16·30 to 26·12 per cent.

The clayband can be traced for a distance of about 2,200 yards from the eastern boundary, with a thickness varying from 18 inches to 4 feet. As known at present, it is estimated to contain 1,250,000 tons of recoverable ore; while if the bed is followed to a vertical depth of 300 feet below the surface, an additional 1,000,000 tons of recoverable ore would be available. Ten representative samples showed an iron content ranging from 50·60 to 55 per cent., with silica from 8·18 to 10·93 per cent., and the first 2,000 tons quarried showed an average of above 50 per cent. of iron.

Area D is a narrow strip of ground within Area C, estimated to contain 250,000 tons of recoverable clayband ore. The iron content ranges from 51·63 to 54·30 per cent., and the silica from 8·31 to 9·85 per cent.

Area E, the Muckleneuk Valley clayband lease, is estimated to contain only 2,200 tons of ore exposed at the surface, and a further 8,000 tons could be obtained by

stripping the bed to a vertical depth of 10 feet. The clay-band here is only about 13 inches thick.

In areas A, B and C there is estimated to be at least 1,000,000 tons of "rubble ore," which occurs as fragments on the slopes below the outcrop of the siliceous ironstone and can be gathered at little cost.

The reserves of siliceous ironstone in the areas included in the lease of the Pretoria Iron Mines Limited may be summarised as follows :

(1) Ore capable of open-cast and adit mining :

	Tons.
Area A	1,900,000
Area B	4,900,000
Area C	9,000,000
Rubble ore	1,000,000
Total	16,800,000

(2) Ore falling within limits of underground mining :

Area B	2,000,000
Area C	10,000,000
Total	12,000,000

The total is therefore 28,800,000 tons, or about 20,000,000 tons if allowance is made for pillars, faults, and patches of low-grade ore. This ore would probably average not less than 45 per cent. of iron.

The reserve of recoverable clayband ore, probably averaging between 50 and 55 per cent. of iron, is 2,510,210 tons, made up of :

	Tons.
Area C	2,250,000
Area D	250,000
Area E	10,200
Total	2,510,200

The cost of quarrying the siliceous ore and bringing it to the blast furnace is found to be well within the estimate of 3*s*. 6*d*. per ton. In large-scale working the cost may not exceed 3*s*. The cost of adit mining is estimated at 6*s*. and of underground mining at 10*s*. per ton.

The clayband ore in Area C can be quarried and put into the furnace bins at 4*s*. per ton, and the cost of underground mining should not exceed 10*s*. per ton. In Area D, where the clayband is thinner, the costs of quarrying and

mining respectively are estimated at 4*s*. 6*d*. and 12*s*. per ton. In Area E the estimated cost of quarrying surface ore and putting it on rail is 4*s*. 6*d*. per ton, and 7*s*. 6*d*. per ton for ore that requires stripping.

Rustenburg District.—A deposit of hæmatite ore in the Rustenburg District is described by A. L. Hall and C. J. N. Jourdan in the *South African Journal of Industries* (1919, **2**, 1118). It is situated 75 miles from the railway on the farm Buffelshoek No. 151, in the Crocodile River Ward, in longitude 27° 22′ E. and latitude 24° 40′ S. The hæmatite is a sedimentary iron ore, representing exceptionally rich portions of the banded ironstone between the Timeball Hill quartzite and the base of the Pretoria Series. It stretches for 2½ miles and consists of three bands of solid hæmatite, 21, 4 and 17 feet thick respectively, separated by two layers of siliceous rock 2 feet and 3 feet thick. The beds dip to the south-east at 45° to 60°. The total thickness of hæmatite, as exposed on the Crocodile River, is 42 feet. Its specific gravity is 5·24, and it gave the following results on analysis:

		Per cent.	
Ferric oxide	Fe_2O_3	93·5	63·3 per cent. of metallic iron.
Ferrous oxide	FeO	2·30	
Alumina	Al_2O_3	0·50	Titanium and chromium together amount to 0·10 per cent.
Silica	SiO_2	3·35	
Phosphoric anhydride	P_2O_5	0·05	
Loss on ignition		0·27	
Sulphur	S	nil	
Manganese	Mn	nil	
Vanadium	V	nil	
		99·97	

The ore is therefore a very high-grade hæmatite, low in silica and phosphorus, and suitable for the acid Bessemer process. How far it retains its character at depth has not been determined. For its economic exploitation a railway connection appears to be necessary, but, with this provided, open-cast mining could be carried on very cheaply. The cost per ton of ore delivered at Pretoria is estimated to be:

	s.	*d.*
Breaking and tramming	3	6
Sorting and bunkering	1	6
Railway freight to Pretoria	3	9
	8	9

Ermelo District.—Near Ermelo a deposit of magnetite is said to yield ore of the following composition :

		Per cent.
Ferric oxide	Fe_2O_3	73·20 [1]
Ferrous oxide	FeO	21·80 [1]
Manganous oxide	MnO	0·45
Alumina	Al_2O_3	0·30
Lime	CaO	0·55
Silica / Insoluble matter	SiO_2	1·95
Sulphuric anhydride	SO_3	0·04
Phosphoric anhydride	P_2O_5	0·284
Combined water and carbonaceous matter		1·40
		99·974

[1] *Together equivalent to iron (Fe)* . . . . . 68·1

During the war the Imperial Institute was consulted as to the possibility of shipping this ore to the United Kingdom. It was stated that 3,000 tons per month could be offered at a price of 40*s.* per ton alongside steamer at Durban. These particulars were brought to the notice of the Ministry of Munitions, who replied that it appeared from the analysis that the ore is of very high quality and compares with C 1 grade of Swedish ore. Owing to the high price and the shipping difficulty, however, it was impossible for the Ministry to purchase the ore.

This is probably the same deposit as that on the farm De Roodeport No. 67, 5 or 6 miles west of Ermelo Station, worked by the Ermelo Coal and Iron Syndicate Limited. The ore deposit is described as forming a bar with a strike almost east and west and dipping north. Between 200,000 and 300,000 tons were practically in sight, and the ore was dug up by picks and bars and loaded into ox wagons for transport to Ermelo station and thence by rail to Vereeniging. Production ceased in February 1918.

Other Deposits.—Around the margin of the red granite of the Bushveld a belt of basic rocks contains large quantities of magnetite in lenticular masses. This is well developed at Onderstepoort, 9 miles north of Pretoria, and at Magnet Heights in Sekukuniland, where 24,000,000 tons are said to be available at the surface alone. The magnetite, however, is highly titaniferous, and this makes it commercially valueless at present. Chromite is also found in the same series of basic rocks. The following

are some analyses made by Prof. G. H. Stanley of the titaniferous magnetites from Onderstepoort.

		(1) Per cent.	(2) Per cent.	(3) Per cent.	(4) Per cent.
Ferric oxide	Fe_2O_3[1] . .	81·43	79·11	76·23	76·41
Titanium dioxide	TiO_2 . . .	15·20	14·10	19·52	18·70
Alumina	Al_2O_3 . . .	3·51	7·79	6·82	4·31
Lime	CaO . . .	0·32	—	—	—
Silica	SiO_2 . . .	0·80	1·36	0·76	1·57
Sulphur	S . . .	0·11	trace	trace	trace
Phosphorus	P . . .	trace	trace	trace	trace
[1] *Equivalent to iron (Fe)* . .		57·00	55·4	53·5	53·6

Banded siliceous hæmatites occur extensively in the ancient rocks of the Swaziland series. Their outcrop is marked by old workings in many cases, but these may have been for the red pigment, and not for iron-smelting. One sample from an extensive old working showed 42·2 per cent. of iron and 33·4 per cent. of silica.

The upper part of the Dolomite Formation contains irregular deposits of earthy manganiferous iron ore, of which those in the Pretoria district have already been mentioned. Hæmatite also occurs between the Dolomite and the Pretoria series in the North Rustenburg District.

Cape Province

In *The Iron Ore Resources of the World*, 1910, A. W. Rogers states that the only deposits of iron ore in the Cape Province known to exist in workable quantity are those associated with the Lower Griqua Town Beds of the Transvaal System. These beds run northward from the Prieska division into Bechuanaland, a distance of 270 miles. Their outcrop covers several thousand square miles, and is bounded on the east by the older limestone of the Kaap Plateau, and on the west by the younger Matsap Beds. They consist mainly of banded ferruginous chert or jasper, and masses of breccia composed of fragments of these banded rocks occupy fissures and hollows in the underlying dolomitic limestone. It is this Blink Klip breccia that constitutes the ore bodies, owing to the concentration of iron in it and the replacement by hæmatite of much of the silica. The breccia forms two prominent ridges, the Klip Fontein Hills and the Gamagara Ridge, as well as

isolated hills. Four specimens from outcrops on these ridges assayed 38·1, 53·0, 56·3 and 67·4 per cent. of metallic iron respectively.

NATAL

In his *Report on the Mines and Mineral Resources of Natal*, 1910, Dr. F. H. Hatch describes iron ore deposits in Swaziland rocks, in Karroo rocks and in Recent formations.

In the extreme north of Natal, between the Pongola and Pivaan rivers, and to the south of the latter, bands of hæmatite-quartz-schist occur in association with quartzite. They strike north and south and dip to the east at about 30°. There are four principal iron-bearing belts, exposed on the farms Bellevue, Paris, Dipka and Palmietfontein, and in places they contain considerable amounts of iron. Similar highly siliceous ores occur in Zululand, in the Umhlatuzi Valley and at Isibudeni in the Nkandhla Forest. In both cases the material is known as "calico rock" and consists of thin seams of oxide of iron alternating with siliceous bands. All these deposits are far too siliceous for smelting in the crude state, and the cost of concentration would probably be prohibitive. Analyses of samples from the three localities mentioned above, dried at 100° C., are as follows:

		Soft hæmatite. Boundary of Palmietfontein and Dipka, Vryheid District.	Hæmatite. Gassett's workings, Umhlatuzi Valley, Zululand.	Sandy hæmatite, Isibudeni Peak, Nkandhla Forest, Zululand.
		Per cent.	*Per cent.*	*Per cent.*
Ferric oxide	Fe_2O_3[1]	62·51	76·17	49·64
Ferrous oxide	FeO[1]	nil	0·45	1·22
Manganous oxide	MnO	5·76	1·20	nil
Alumina	Al_2O_3	2·21	7·10	3·11
Lime	CaO	1·45	0·90	0·87
Magnesia	MgO	1·76	0·47	0·36
Silica	SiO_2	24·15	13·13	44·44
Phosphoric anhydride	P_2O_5[2]	0·063	0·039	trace
Titanium dioxide	TiO_2	nil	nil	nil
Combined water and organic matter		2·43	0·52	0·54
		100·33	99·98	100·18
[1] *Together equivalent to iron (Fe)*		43·76	53·70	35·02
[2] *Equivalent to phosphorus (P)*		0·028	0·018	trace

In the Karroo rocks a bed of iron ore is met with in many localities in the coal-bearing Ecca Sandstone, below the workable coal seams. The bed is always a thin one, but the ore is of fairly high grade, low in silica, free from titanium, and with variable amounts of phosphorus.

At Prestwick, 10 miles north-east of Dundee, the bed is about 2 feet thick and lies nearly horizontally between sandstones. The ore is specular hæmatite, with some magnetite and limonite, and the phosphorus varies from 0·127 to 0·198 per cent.

At Doornberg the ore is chiefly magnetite, and the phosphorus ranges from 0·128 to 0·152 per cent. A similar magnetite occurs at Mount Kelly, Greytown, but it contains only a trace of phosphorus. At Sweetwaters, 6 miles north of Maritzburg, the ore appears to be a limonite with a thickness of about 4 feet. Phosphorus varies from 0·108 to 0·436 per cent.

The following analyses were made on material dried at 100°C.:

		Prestwick.	Doornberg.	Mount Kelly.	Sweet-waters.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Ferric oxide	Fe_2O_3[1]	81·19	71·10	74·37	78·63
Ferrous oxide	FeO[1]	5·25	19·84	17·79	nil
Manganous oxide	MnO	nil	nil	0·25	0·28
Alumina	Al_2O_3	3·33	2·08	1·18	5·56
Lime	CaO	1·12	1·12	0·65	0·81
Magnesia	MgO	1·06	3·84	4·72	1·02
Silica	SiO_2	4·93	0·67	1·02	4·13*
Phosphoric anhydride	P_2O_5[2]	0·433	0·293	trace	0·487
Titanium dioxide	TiO_2	nil	nil	nil	nil
Combined water and organic matter		2·78	1·17	0·72	9·95
		100·09	100·11	100·70	100·87
[1] *Together equivalent to iron (Fe)*		60·89	65·14	65·58	55·04
[2] *Equivalent to phosphorus (P)*		0·189	0·128	trace	0·213

* *Matter insoluble in hydrochloric acid.*

Superficial iron ores of recent age are common in Natal. They are mostly limonitic, low grade and of small thickness. An average sample from a deposit at Alverstone contained 44·5 per cent. of iron, 9·3 alumina, 16·82 silica, 9·06 combined water, and 0·075 phosphorus.

MINING DEVELOPMENTS IN NORTHERN MANITOBA

Northern Manitoba, which extends from 52° 50′ to 60° north latitude, and has an area of 178,100 sq. miles, was added to Manitoba in 1912, thus giving it a seaboard and increasing its area three and a half times. The territory has been, up to the present, mainly fur-producing, but now is becoming prominent as a potential source of mineral wealth. A large proportion of the country consists of lakes, close to which most of the mining properties have been discovered, and in view of this fact the extensive use of the hydroplane for both prospecting and initial development has recently been proposed. This may advance the opening-up of a huge, almost unknown, district by several decades.

The chief mining centre is The Pas, formerly the site of a mission station, which is 350 miles, in a direct line, north-west of Winnipeg, and on the Central Northern Railway, almost completed to Port Nelson, on Hudson's Bay.

There has been much active prospecting and developing recently, especially since the beginning of 1916, on an east-west mineral belt, about 90 miles north of The Pas, and about fifteen miles wide, where a large number of mining properties have been discovered, some valuable.

As a rule the ore occurrences are found in greenstone schist or associated porphyry of Huronian (pre-Cambrian) age, which is here and there intruded by granite.

The Mandy mine, owned by the Tonopah Mining Company, found in 1915, is situated at the north-west of Schist Lake, about 10 miles north of Athapapuskow Lake. So far it is the only mine that has been worked in the district. Its nearly vertical lode lies in a schisted and faulted zone in a greenstone formation; is 225 feet long and 40 feet wide; and has been proved to a depth of 200 feet. Below this the lode narrows. It formerly had a lens of very high-grade chalcopyrite ore—since worked out—containing 17 per cent. copper, surrounded by a chalcopyrite-blende-pyrite deposit of low value (1¼ per cent. copper). During the summer of 1917, 3,335 tons of high-grade ore were shipped with great difficulty and at great

expense *via* The Pas to the Trail smelter, a distance of 1,670 miles, and yielded 337 oz. gold, 60 oz. silver and 557 short tons of copper (= 17 per cent.). Altogether 25,000 tons of high-grade ore have been shipped to the smelter. Its reserves of lower-grade disseminated ore are estimated to be 200,000 tons, but the future of the property depends upon the opening-up of the district by a railway and the erection of a Customs smelter in the neighbourhood.

At Flin Flon Lake, about 4 miles north-west of the last camp, and on the boundary line with Saskatchewan, a body of low-grade copper sulphide, discovered in 1915, has been prospected by diamond drilling for a length of 1,000 feet, and to a depth of 900 feet, and is estimated to contain 20,000,000 tons of ore, averaging gold 0·074 oz. and silver 1·04 ounce per ton; copper 1·69 and zinc 3·49 per cent. A central lens of solid sulphide consists of pyrite, sphalerite, chalcopyrite and magnetite, with gold and silver. The disseminated ore on the hanging-wall is low grade in copper and fairly rich in gold and silver, whilst in the footwall the disseminated ore is of high grade in copper and of lower grade in gold and silver. The size of this property alone justifies the building of the proposed eighty-five-mile railway from The Pas to the neighbourhood. It has been recently reported that Col. William B. Thompson and associates of Toronto have taken an option on the property for about $1,500,000 cash, and have agreed to spend $200,000 during the option.

On the north shore of the east arm of Lake Athapapuskow, large bodies of sulphide ores, running from 2½ to 4 per cent. copper, were located in 1918. The ores, consisting of chalcopyrite and bornite, occur in bunches, stringers and isolated crystals in schisted bands in the greenstone. Near the mouth of the Pine Root River, immediately west of the rapids, a narrow zone of sheared porphyry, intruded on the west side by granite, and flanked on the east by conglomerate, has been impregnated by pyrite and scattered crystals of chalcopyrite. It is understood that a lens of chalcopyrite has been reached at depth on the contact between the conglomerate and porphyry.

In addition to the above there are many indications of copper in other parts of the belt. The remarkable extent

of the large bands of iron sulphides, associated with big quartz lodes, has given great encouragement to the prospecting for copper—possibly in association with nickel, gold or platinum.

Recently much attention has been given to gold mining, especially in the siliceous zones of the Herb and Copper Lake districts. Gold-bearing veins were discovered in 1914, on the eastern end of the mineral belt in the vicinity of Herb Lake, reached from Mile 82, on the Hudson Bay Railway. The gold is associated with pyrite, arsenopyrite (especially on the margins and in the walls) and copper sulphides (sparingly present). The vein thus far developed shows an average thickness of about 3½ feet with high values throughout. The country is a complex of coarse sediment (in places conglomerate) and acid lavas. In the quartz there is considerable arsenopyrite, a little calcite, and, here and there, lenses of pyrite. In 1918, 433 tons of ore yielded 365 ounces of gold (820 fine). The mine has been temporarily closed down. On the Apex property a wide cone of granite has been silicified near its contact with greenstone, and good assays were obtained over a width of from 20 to 25 ft. of quartz and altered granite. From surface indications this would appear to be a very large ore-body. From the Moosehorn, early in 1917, 17,000 tons of ore were stripped, which yielded on smelting an average of $81·53 per ton. The vein is from 6 to 30 in. thick. The gold is associated with arsenopyrite and tourmaline.

In the Copper Lake district, a few miles west of the centre of the mineral belt, a large quartz lode, mineralised with galena, was very recently found to assay $9·00 in gold over a width of 20 ft., and a few months ago a parallel quartz vein was discovered extremely rich in native gold.

There are numerous other gold-bearing properties in the neighbourhood awaiting development, and much capital will be required for shaft-sinking and other exploration work. With the encouragement of the natural market for gold at the present time the necessary capital should be forthcoming without difficulty.

Owing to the action of the Imperial Institute in 1915 in issuing a circular on molybdenum and the necessity for its

increased production in the Empire, and to the furtherance of the matter by the Canadian Mines Department, there has been active searching for molybdenite deposits in Canada, resulting in important finds in Quebec, Ontario and British Columbia. At present, as there are reasons for anticipating a big demand for molybdenite for alloy-steel-making in the near future, it is interesting to note that Manitoba is also likely to become a producer.

Molybdenite has been found at the south end of Phantom Lake, south of Mandy. The mineral occurs in a vein of quartz, in places parallel to the veins, and associated with pyrite and a little chalcopyrite. It occurs near the granite contact with greenstone. On another property on the same lake, quartz in very narrow shear zones carries pyrite and chalcopyrite, with molybdenite on the shear zones.

On some claims near Copper and Brunne Lakes, near the centre of the mineral belt, the characteristic sulphides are molybdenite (in flakes in the fissures in the quartz) and pyrite.

Near Herb Lake, at the eastern end of the mineral belt, considerable shavings of molybdenite have been obtained in a quartz vein.

On the west side of Brunne Lake, near the centre of the belt, there is an occurrence of almost solid pyrite and pyrrhotite. Gold, copper, nickel and platinum have been found, but no systematic sampling has been done.

Near Turnberry, within Northern Manitoba territory, some indications of oil have been found in springs at the foot of the escarpment and several oil claims have already been staked in the vicinity of the springs. In the same region, shales, interbedded with thin bands of limestone, of Cretaceous age, may prove to be oil-bearing.

Much of the data given above has been derived from the pamphlet *Mining and Mineral Prospects of Northern Manitoba* by Professor R. C. Wallace, Mining Commissioner at The Pas, and published by the authority of the Government of Manitoba.

THE CONDITIONS AND POSSIBILITIES OF BRITISH TRADE WITH MOROCCO

THE Department of Overseas Trade recently commissioned Messrs. E. Homan Mulock and L. N. Barker, B.Sc., to visit Morocco and investigate the possibilities and conditions of trade between that country and the United Kingdom. The Report drawn up by them exceeds 130 pages, and is illustrated by an excellent map, showing shipping, railway and main road routes, and the chief natural products over the whole country. It is full of matter of the greatest possible interest to the merchant and manufacturer, whether concerned with export or import trade, and to the would-be settler or capitalist concerned in the development of the natural resources of the country. Only a few of the more salient points in the Report can here be dealt with.

AGRICULTURE AND LIVESTOCK

The agricultural section embodies a report on the prospects for settlers in the French zone that has already appeared in the *Board of Trade Journal*, and another by an Australian Mission, dealing mainly with sheep-raising, from the *Bulletin Officiel* of June 2, 1919, with notes on experimental results in the French zone. Little or nothing is done in the Spanish zone to encourage agriculture; arable land is abandoned to grazing; food supplies have to be obtained from outside; and there are neither means of gauging possibilities nor apparent openings for enterprise.

The rains in Morocco only fall during winter, many of the rivers drying up completely in the summer; but the mountain water-supply, if harnessed, could supply both power and irrigation, and there is a good supply of water at a depth of 30 to 40 feet all over Marrakesh plain. Afforestation with quick-growing trees is recommended for the provision of fencing as well as the regularising of the rainfall. The short life of the spring pasturage suggests the necessity of the storage of fodder, either in the form of beet and mangolds or of ensilage. Clover and other leguminous plants flourish in the natural pastures, and hay under irrigation should prove very profitable. Wheat,

barley, beans and peas yield, with poor methods of cultivation, sufficiently to demonstrate the fertility of the soil, and the leguminous crops should be grown on a large scale preparatorily to wheat. Dry farming can be seen in operation at the 1,500-acre experimental farm near Fez, and the French authorities have taken steps to encourage the cultivation of soft wheats in addition to the hard wheats now grown for semolina, of castor oil, early potatoes, sugar-beet and cotton. Egyptian medium-stapled cottons, such as Mitafifi, and American types, such as Nyasaland Upland, are indicated as most promising varieties ; but in several recent years the experiments have been greatly handicapped by locusts. The abundance of fruit, including dates, figs, grapes, apricots, nectarines, melons, oranges and lemons, grown round Marrakesh suggests that, with irrigation and a six-day transport to England, a large export trade might be established, if the natives were taught grafting, picking, grading and packing.

The dwarf palm or palmetto (*Chamaerops humilis*, Linn.), for which the native name is "doum," is ubiquitous in Morocco, the most pressing need of the agricultural districts round Fez and Mequinez being stated to be an effective machine for removing its roots from the soil. About five plants occur to the square metre, and their roots penetrate from 8 to 24 inches. In the Oudjda district the roots of jujubier (*Zizyphus* sp. ?) are almost equally troublesome. As the soil is sometimes rocky, and it is undesirable to bring poor sub-soil to the surface, it is suggested that what is required is heavy disc ploughs, with discs 28 to 32 inches in diameter, and a readily adjustable depth regulator (10 inches being the average depth to be ploughed), worked on a cable between stationary steam-tractors burning roots as fuel. The present cost to the farmer of the clearing of the land is about 400 francs per hectare ; and it is suggested that syndicates in the principal agricultural centres equipped with such ploughs, and a staff of trained mechanics to work them, might very profitably contract to clear the land at a less cost to the farmer.

There are about four million sheep in Morocco, but the wool is of poor character. Australian Merino stock (of Moroccan origin a century ago) for the interior,

and Romney Marsh for the coast, should be introduced in Government stud-farms; and dipping baths should be constructed to demonstrate the value of a chemical bath after shearing. Initial essential changes of method are that the rams should only be left two months with the ewes; the ewes should not have lambs until two years old; the ewes should not be milked; the tails of all lambs should be cut; and all males not required for breeding should be castrated. The custom of leaving the wool on the stomach is troublesome to the animal, and entails an annual loss of £60,000. The best results will not be obtained with sheep until it is possible to leave them to graze freely in open fields. Similarly, improved breeding by the introduction of stud bulls of milking breeds, the not stocking cows less than two years old, the castration of heifers when three or four months old, a sufficiency of water and better feeding, would give cattle weighing as much when three years old as they do at present at six, and permit a considerable export of meat to Europe. The breed of saddle horses has been improved by the State introduction of 350 stallions; but light draught horses and mules might also be usefully bred. The breeding of pigs, which have increased to 60,000 in the course of four or five years, appears to have proved exceptionally profitable, small capital doubling itself in a year or two, though the labour involved must be entirely colonist. Meat-salting factories already exist at Meknez and Kenitra; but refrigerating slaughter-houses either at agricultural centres or at the ports are still a desideratum. Booklets 10 and 15, issued by the Director of Agriculture at Casablanca, deal respectively with pig-breeding and stock-raising in Morocco.

The cost of land in Morocco is decidedly high, being about 200 francs (£8) per hectare (2½ acres) for land cleared but not irrigated, and 2,500 francs for that both cleared and irrigated; legal proceedings are difficult and dilatory; a knowledge of Arabic, Spanish and French is indispensable for dealing with workmen, foremen and local authorities; the absence of timber necessitates the use of laboriously quarried stone, or of mud for building; and the scarcity of water adds to the hardship of up-country

life. Morocco is not, therefore, thought to be a favourable field for farming enterprise by the individual English settler; but it is suggested that the most practical form of British participation in the development of the agricultural possibilities of the country is by amalgamating with French companies or colonists already possessing the essential experience of the local conditions.

Timbers

Morocco seems to be very poorly supplied with timber for building purposes, the only three species at present exploitable by contractors in the French zone being the Atlas cedar, the cork oak and the thuya or arar. The forests occupy four well-defined zones :—(*a*) the cork-oak and thuya zone, from 2 to 100 kilometres from the coast in the Rabat and Chaonia regions, with the ports of Rabat and Kenitra and the Salé-Fez railway ; (*b*) the cedar and evergreen oak zone on the lower slopes of the Middle Atlas, south of Fez and Meknez, at about 200 kilometres from the coast ; (*c*) the argan and thuya zone of the Mogador and Agadir littoral, extending 150 kilometres inland to the foot of the Atlas ; and (*d*) the evergreen oak, Aleppo pine and thuya zone of the unpacified Grand Atlas. The cork oak attains exploitable dimensions at twenty-five years of age (half that required in Algeria) and the cork can be harvested in eight years, instead of ten, after the removal of the virgin cork. The inner bark has been largely used for tanning and the wood for charcoal ; but these destructive uses of the tree are now prohibited. From the evergreen-oak forests of the Middle Atlas, however, 100,000 sleepers were taken for a military railway at the close of 1916, and the Protectorate authorities propose to use still more for projected broad-gauge lines. About the same time cedar planks were marketed by the Forestry Service at a rate of 3,000 per month, increasing to double that number and more, this being the chief building timber in the country ; but the most extensive cedar forests, which are said to cover 350,000 hectares, are above the 1,400 metre level in the unsubdued part of Morocco. The thuya or arar (*Tetraclinis articulata*, Masters) in the south is the source of gum sandarac, most of which is taken by the

United Kingdom, *viâ* Mogador, our import averaging £20,000 per annum in value. The species also occurs east of Rabat and Casablanca and the forests have been exploited to supply wood for carpentry and cabinet-work. The argan (*Argania Sideroxylon*, Roemer and Schultes), peculiar to Southern Morocco, where it covers hundreds of thousands of hectares, reaches no great height, but is sometimes of considerable girth. Its dense wood is only used for charcoal; the fruit husk is eaten by cattle, whilst the kernel yields a disagreeably-tasting oil which is appreciated by the natives.

Tanning and Dyeing Materials and Leather Industry

The two most interesting local industries of Morocco are the tanneries and the trades concerned in the utilisation of the dwarf palm or palmetto. Messrs. Mulock and Barker have wisely incorporated in their Report detailed descriptions, by the British Consular authorities at the centres of the leather industry, of the materials and processes employed in the tanneries of Rabat, Marrakesh, Meknez and Fez. From these it appears that, as regards vegetable tanning extracts and dyes, Morocco is likely to be always more an importer than an exporter. Orchil, recorded from the "Barbary States," comes apparently from the Canary and Cape Verde Islands: chestnut extract is imported from France; cochineal from the Canary Islands; and alum and aniline dyes from Europe.

A collection of small samples of local products from Marrakesh submitted by the Mission to the Imperial Institute included two possible tanning materials:—some hollow orange or reddish galls known as "Yig," apparently rich in tannin, used in tattooing Moorish women's faces; and "takout," the small irregular brown hard galls of *Tamarix articulata*. These latter galls occur in South Morocco; but are apparently much poorer in tannin than those brought from Tafilet and the Wadi Draa, which were exported to Marseilles before the war, and are said to contain 43 per cent. of tannin. The tanneries of Fez, Marrakesh and Rabat only use the takout from beyond the Atlas.

Among other materials employed that are of local

origin are lime, procurable in most parts of Morocco; pigeons' dung, furnished locally by the thousands of birds which inhabit the old walls of Meknez; wheat bran; dried black figs; oak bark and that of the Aleppo pine (" tsnoober "); madder (*Rubia peregrina*), " ta'rubia "; " marghatah," the stalks and leaves of *Osyris lanceolata*, a Santalaceous plant allied to the Cape sumach of South Africa; and the yellow powdered rind of the pomegranate gathered unripe and dried in the sun. The native tanners of Rabat reckon " taida," the powdered bark of the " tsnoober," to be more effective than " fernan," the bark of the cork-oak of the Mamora forest, in the proportion of 2 to 5. The Département des Eaux et Forêts is trying to supplement the already insufficient supply of cork-oak bark for tanning with that of the evergreen oak. *Pistacia Terebinthus*, Linn., the Chian turpentine tree, common throughout the Mediterranean region, is stated to be used under the name of " b'tama " in tanning, its berries being used as a substitute for takout, and also for red and black dyes; but the resin does not appear to be collected. The dried and pulverised leaves and root of the allied sumach (*Rhus pentaphylla*) are used, under the name " tizra," as a yellow dye; but not in tanning. This tree exists in fairly large quantities on the lower Atlas slopes in the north-east, and might become an article of export from the northern ports. The spurge-flax, *Daphne Gnidium*, Linn., the " sain-bois " of the French, known as " el luzaz," is used, mixed with ferruginous clay, for black dye; and, in conjunction with " m'ghair," a species of *Phillyrea*, for green.

Owing to religious scruples, no pig skins are at present tanned in Morocco; and the native tanner considers goat skin to supply the best and most durable leather. The processes employed differ somewhat at the various centres of the industry. The best Morocco leather, used for bags, belts, saddles and cushions, is known as " filali " or Tafilet leather, but is manufactured, from goat skins, at Marrakesh, by the following process:—Four baths of lime of different strengths serve to remove all hair, flesh, etc.; the acidity requisite to neutralise the last traces of the lime and to open the pores of the skin for the absorption of the tan is obtained by short successive fermentations with pigeons'

dung and bran; the actual tanning is carried out with a concentrated solution of takout; and finally the leather is dyed, either red with madder and alum or yellow with pomegranate rind. Most of the leather produced in Morocco is manufactured into slippers, either for local use or for the long-established export trade to Egypt and Senegal. The chief centres of this trade are Fez, where 20,000 persons are employed and the export in 1913 reached a value of £400,000, Marrakesh, where the tanneries employ 6,000 men, Tetuan and Rabat. Most of the slippers are dyed canary yellow for men's wear, or dark red for women's out-door use; but cream-colour, blue, purple and green slippers are worn by Moorish women indoors, and by Jewesses; and there is an opening at Tetuan for the introduction of silver thread, or other material, to ornament these. Since the outbreak of the war the value of the export trade in slippers has fallen 50 per cent., and only 500 men are said to be actually employed at Fez in tanning, with about 100 or 150 learners. Four different kinds of leather go to the making up of Moorish slippers, viz. goat skin, "zeewania," for the uppers; sheep skin, "battana," and calf skin, "ajeelie," for the linings; and bullock hide, "nalla," for the soles. Zeewania is tanned by the same process as filali leather; but is only dyed with pomegranate rind and alum. Battana and ajeelie are given three baths of lime and are then treated in succession with bran ("nkhal"), figs, salt and "dabbagh," the powdered bark of the "tsnoober" or Aleppo pine or of oak, the battana being finally dyed red with cochineal or yellow with pomegranate rind. At Rabat the bath of extract of dried black figs is now omitted. Bullock hides for sole leather ("nalla") are first treated with salt and then have three baths of lime, followed by fermentation with bran and tanning with oak bark. At Fez and Meknez another tan is employed, either alone for specially soft white leather, or followed by treatment with pine bark in the case of ox and cow hides, and with takout also in that of sheep skins. This is the dried and powdered stalks and leaves of the "marghatah" or "mahrata" (*Osyris lanceolata*).

With the exception of the yellow obtained from alum

and pomegranate rind, the native dyes are now replaced or supplemented by imported anilines; and this is true also of the silk-dyeing industry at Tetuan. These aniline dyes, obtained before the war from Germany, are now procured from St. Denis, near Paris. The French authorities at Rabat are encouraging the revival of the use of the native vegetable dyes, such as madder, Daphne, pistachio, pomegranate and henna, with imported cochineal and indigo, for the woollen carpet manufacture. In this process alum is used as a mordant with the addition of sugar, dates or other sweet fruit to induce fermentation.

Dwarf Palm Industry

The dwarf palm or palmetto, as already mentioned, is ubiquitous in Morocco. The natives employ the leaves of the palm for plaiting flat wide baskets ("couffites"), costing 2½–3 francs each, larger baskets ("couffins"), costing 4 or 5 francs, large panniers ("chouaris"), costing 4 to 10 francs, and mats, ornamented in coloured wools; and in making rope and brooms; but it appears doubtful whether the industry is susceptible of expansion with a view to export. The grubbed-up roots are sold to Europeans for fuel, but the chief European palmetto industry is the manufacture of crin végétal (vegetable horsehair) from the leaves bought from the natives. Twenty-four factories are already installed at Casablanca and others at Rabat and Mazagan. The cut leaves are bought from the natives at the factory at 25 to 50 francs per metric ton; they yield, when carded and spun, 50 per cent. of crin végétal, which sells at 430 to 600 francs a ton. Rope is made at some factories, and attempts have been made to produce paper-pulp from palmetto.

Minerals

The mineral resources of the country exist mostly in the mountainous regions of the Atlas and the Riff which are as yet neither fully explored nor brought under law and order. Small samples derived from the French zone have been examined at the Imperial Institute, and reports on the more interesting are given in this Bulletin (p. 29). They include good iron ores, suitable for the

production of steel by the acid Bessemer process, galena, manganese ore, and a promising nickeliferous oxide of iron and arsenic. Petroleum is stated to exist at Petit Jean in the French zone. The Protectorate Government intends to exploit the extensive phosphate beds round El Boroudj, seventy-eight miles south of Casablanca, on its own account. These deposits, which, like those of Tunis, are of Eocene age, have been valued at £3,600,000,000. It is intended to construct a special mineral line from El Boroudj to Fedala, a port a few kilometres from Casablanca, which is to be fully equipped for the shipment of minerals.

The only minerals being worked as yet on any scale in Morocco are those of the Riff in the Spanish zone in the neighbourhood of Melilla, where there are three considerable iron mines and one working lead and zinc ore. The most important is that of the Cia. Española Minas del Riff, working large superficial masses of excellent specular hæmatite, averaging 63 per cent. of iron, by opencast, at a present output of from 15,000 to 20,000 tons a month. The company intend building a mechanical loader with a capacity of 600 to 700 tons per hour at Melilla harbour, at an estimated outlay of £120,000. The company's concession exceeds 2,000 hectares, and in about two years they have extracted 400,000 to 500,000 tons, the Moors being supposed to have taken out 300,000 tons previously. The Setolazar Company, working the Navarrete Mine, has an equally extensive concession, estimated to contain more than 4,000,000 tons of iron ore; in 1918 they shipped 61,000 tons, all to the United Kingdom, their present output being 300 tons daily. The Norte Africano Co. have a monthly output of 200 tons of lead ore from pockets near the surface, worked on inclined planes, averaging 82 per cent. lead, all shipped to Cartagena, in addition to calamine estimated to contain 40 per cent. of zinc. Deposits of specular and dark hæmatite likely to prove valuable are known to occur in the unpacified zone west of Melilla, within 5 or 6 kilometres of the sea. From the neighbourhood of Tetuan, where as yet only a small area has been pacified, samples have been sent to the Imperial Institute, including brown hæmatite containing 80·7 per cent. of

ferric oxide and 4·96 per cent. of manganous oxide, which might be used for spiegeleisen; some other hydrated iron oxides, containing rather more phosphorus than is admissible for Bessemer steel; and a high-grade galena. Coal, platinum, mercury, sapphires and copper ores are also reported from this region, and it is suggested that a British mining engineer should be sent out to survey, with powers to buy claims right out.

Possible New Industries

In the Spanish zone the manufacture of soap and candles is suggested as likely, with a large capital, to be very remunerative. Pure olive-oil soap for textile manufactures and blue mottled soap with an olive-oil basis are indicated as specially in demand not only in the towns with a large proportion of Europeans, but also for the natives of the interior. While large supplies of olive oil and animal fats, stearine and beeswax could be obtained locally, these manufactures would necessitate the importation of caustic soda, ultramarine, cobalt blue and various cheap hard oils and resins. The natives prefer intensely blue soap. It is not probable that any such local manufacture would seriously interfere with our existing import trade. Before the war, the United Kingdom supplied Morocco with the greater part of her imports, both of soap and candles; but latterly French supplies have been approximating to the British, and Italy has entered both markets, some candles also coming from Antwerp and Holland. What is required is a cheap candle that will withstand the summer heat, the natives largely using paraffin candles and the Europeans stearine. The latter cannot be used in mosques. The Moors are taking to the use of highly perfumed toilet soaps, which appeal strongly also to the Jewish community; so that these soaps, in spite of French and Spanish competition, constitute a promising opening for import trade.

Other industries suggested for initiation in the Spanish zone are the crushing of the abundant local supplies of linseed and castor seed, and the manufacture of alcohol from the long-naturalised Indian Fig cactus (*Opuntia Ficus-indica*, Webb), "higo chumbo."

Not so very long ago the production of silk in Morocco employed 10,000 persons and occupied 20 throwing and 500 primitive weaving looms. The French authorities have, since 1914, revived sericulture around Fez, a large silk-dyeing centre, and two Englishmen made a successful experiment with French pasteurised eggs at Marrakesh in 1909 ; but this can only become a native peasant-industry.

Other openings for British enterprise of a non-agricultural character within the country discussed in the Report are the establishment of laundries for Europeans at Casablanca, Rabat and Tangier, where the European population numbers 37,500, 9,748 and 8,000 respectively ; of a series of first-class hotels at Casablanca, Rabat, Meknez, Fez, Marrakesh, the slopes of the Atlas beyond that place, and Mogador, for tourists and invalid visitors, with English managers and Moorish-speaking sub-managers, linked up by motor-car services and with a system of steamers, such as the R.M.S.P. fortnightly boats ; of public warehouses at the chief ports which would permit of the gradual withdrawal of goods by consignees without the heavy increase of Custom dues ; or of a British universal or general store at Tangier for the sale of British goods.

Openings for Import Trade

The Report, in dealing with the possibilities of the future import trade, repeatedly urges the co-operation of non-competing firms in sending out agents, inspectors of native agencies or travellers, and in the establishment of sample depots and showrooms. This is especially recommended in the cases of builders' ironmongery and machinery, though it would seem that such a central store as is contemplated could well also include general hardware, tools, electric and motor appliances and, perhaps, earthenware and glass, paints, cement, chemicals and furniture. A central depot at Casablanca is suggested, with branches at Marrakesh, Rabat, Kenitra, etc. With the employment of native local agents, tours of inspection are necessary, at least annually ; it is almost impossible to do any business in Morocco by correspondence, samples being of vital importance ; and competent travellers, with a knowledge

of Arabic, and of French or Spanish according to the zone worked, are essential. The requirements of two classes of customers, the large European population in the towns and the natives, have to be borne in mind, the former, for instance, requiring light woollen goods from October to March, while the native Jewish population are now adopting European costume, generally of a rather showy appearance, and the Moors also purchase shoes of European make, if fastening so as to be readily removable. "Melf," a cloth dyed in the yarn, used by the better-class Moors as a kaftan, is especially in demand; before the war it was largely supplied in bright colours from Central Europe; but substitutes from the United Kingdom have not supplied a bluish white material, and have not been sufficiently bright in colour. Most British woollens have been too good, and consequently too costly for the market. Cotton goods are the largest and most firmly established of British exports to Morocco, averaging about nine-tenths of the total import of cotton, France being the only serious competitor.

Other classes of goods discussed as being in request include Chinese green tea, with an amount of black tea increasing with the European population; cheap stationery, including account books ruled double, *i.e.* for francs and centimes, not for pounds, shillings and pence; strawboard, required in the slipper manufacture; cheap electric light fittings and cotton-covered wire; telegraphic instruments and constructional material, in conformity with the specifications of the French Administration; a considerable amount and variety of constructional steel and iron; mining tools, steel cable and dynamite at Melilla; gas-engines from 6 to 200 h.p., with producers adapted to burn refuse; Diesel and semi-Diesel engines; a petrol or paraffin-driven farm pump; a light travelling thrashing and winnowing mill driven by a petroleum motor, which could be hired to the farmer; motor-buses of the Peugeot type, about 35 h.p. with 1,000 kilograms (1 ton) tare, carrying 3,500 k. (3½ tons) 250 kilometres (160 miles) a day at maximum speed of 18 miles per hour, for passengers and mails; moderately light private motor-cars with a clearance of at least 10 inches, jacks being sent with

every car, with a good supply of pneumatic and solid tyres and spare parts, expert English mechanics accompanying any new machinery sent out to demonstrate and repair, while instructions in French for the use of agents are also essential; a range of sizes of tins containing white lead, linseed oil and mixed paints; glazed earthenware drain pipes, 18 in. by 2 ft. or 1 metre, especially at Tetuan and Tangier, using metric measurements; Portland cement, made up in casks of 100 and 120 kilograms, *i.e.* less than half a camel-load, to compete with Swedish material; industrial chemicals, such as alum, caustic soda and superior indigo; and cheap sewing machines which can be sold for small weekly instalments.

Many of these classes of goods could, it is suggested, be stocked by a general machinery and hardware store at Casablanca; and there is an opportunity at present for British manufacturers of drugs, perfumery, etc., to enter into an arrangement with an old-established druggist.

Goods packed for Morocco should be made up in bright-coloured, showy wrappers, and a liberal use of packing material such as canvas, tarpaulin, cardboard, tin-lining and wooden cases which can be used again will add to the saleability of the contents. The Report urges the publication and gratis distribution of a monthly journal, devoted to British commercial interests, consisting largely of advertisements which would cover its cost, and printed in French, Spanish, English and Arabic. The consensus of opinion is that all imports should be quoted c.i.f. Morocco port. Considerable credit must be given; but, while the Bank of British West Africa and the Banque d'État clear goods through the Customs, warehouse them for delivery in instalments, collect drafts and discount bills, it is suggested that a company amalgamating British and French capital to finance such enterprises as the provision of machinery and plant for public works, or other mercantile agency or industrial undertakings, registered under Moorish law, on the lines of the Compagnie des Chargeurs Marocains, might greatly assist our trade. An existing French firm at Rabat are willing to co-operate with a group of British firms in the establishment of such a warehouse of machinery as is suggested in the Report; but the Commissioners

make the further recommendation (affecting our trade in engineering material in general, and not only to Morocco) that a Bureau de Réception should be established in England, similar to the French Bureau "Veritas," in the shipbuilding industry and to various Bureaux in America, with laboratories and specialists, to prepare specifications and, still more, to test materials, component parts and machinery, so as to certify them before shipment as being in accordance with specification.

The Report states the conclusion that there will always be a shortage of return cargo from Morocco to the United Kingdom, so that a call at a French port will probably be necessary on a return voyage. When, in 1917, the total exports of Morocco reached their highest value, about £5,300,000, the share of the United Kingdom was little over a tenth of that amount; but, with the removal of war restrictions on the export of cereals, with irrigation and modern agricultural methods, with the pacification of the country, and the organisation of transport, both internal and external, there is no doubt that both these figures can be largely exceeded.

Need for Shipping Facilities

The Report concludes by pointing out that the extent to which British trade can profit by the openings described depends in a considerable degree on the provision of British shipping facilities. Before the war the Royal Mail Steam Packet Company ran a fortnightly service of boats primarily for tourists, while the German Oldenburg Steamship Line, with twenty to twenty-four vessels, by studying the needs of merchants in Morocco captured a large proportion of British cargoes and also of British trade.

Conclusions

In addition to measures calculated to improve the agriculture of the country, which would tend ultimately to the extension of the export trade in wheat, barley, early potatoes, cotton, beet-sugar, castor oil, and wool, the principal suggestions of the Report with reference to the French zone would seem to be the following:

1. A more frequent and regular service of British trading steamers.

2. The publication of a monthly trade advertising journal in English, French, Arabic and Spanish for gratuitous circulation.

3. The establishment at Casablanca of central showrooms and stores for ironmongery, agricultural machinery, pumps, gas-engines, general hardware, cement, paints and chemicals.

4. The extended import of cheap woollens, stationery and Chinese green tea.

5. The possible production for export of bacon and cork.

6. The establishment of a series of hotels connected by a motor service for tourists from the coast to the chief towns and the foot of the Atlas ; and

7. The opening of laundries in the towns with European populations.

For the Spanish zone, the chief suggestions are :

1. That possibly valuable mining concessions, especially of hæmatite, are to be had.

2. That good iron ore, extracted by Spanish companies, can be exported.

3. The locally abundant supplies of linseed and castor seed might be crushed ; and

4. That a manufacture of soap and candles from local materials for local consumption might be established.

Concerning trade other than that with Morocco there is the recommendation as to the establishment in England of a central testing and standardising station for machinery and engineering material.

RAW MATERIALS COMMITTEE OF THE IMPERIAL INSTITUTE

A meeting of the Raw Materials Committee of the Imperial Institute, nominated by the Association of British Chambers of Commerce, was held at the Imperial Institute on January 22, 1920. In the absence of Sir Algernon Firth, Bart., Mr Arthur M. Samuel, M.P., took the chair.

The following précis of the proceedings is published for general information.

In addition to other business the Committee considered the commercial aspects of the following raw materials which have been investigated recently at the Imperial Institute.

(a) Progress Reports

Hat-making Materials

The enquiry relating to possible sources of supply within the Empire of hat-making materials suitable for use by British manufacturers has been continued.

Since the last meeting of the Committee a collection of hat-making materials and hats of native manufacture from the Gold Coast has been received and submitted to the Luton Chamber of Commerce.

The Chamber considered the workmanship of these specimens to be excellent, and forwarded a range of sample plaits, hats, etc., to the Imperial Institute for transmission to the Gold Coast as patterns for the guidance of the natives. These specimens have been taken to the Gold Coast by a Government official, who is interested in the question and has promised to make efforts to stimulate the production of straw plait and hats for export.

Other samples of materials and plaits from West Africa and the West Indies have also been received, some of which appear likely to be of interest to Luton manufacturers.

Cinchona Bark from East Africa

In continuation of the investigation of samples of cinchona bark from plantations in German East Africa, which was referred to at a previous meeting, a consignment of 3½ tons of the bark has since been received from the Administrator of that country, and has been sold to a British firm of quinine manufacturers at the price of 5¼*d.* per lb. for the chips and 11*d.* per lb. for the quills.

The results of the investigation are very promising and show that cinchona bark of good quality can be grown in German East Africa. The plantations were partially destroyed by the Germans before the surrender of the country, but it is hoped that the cultivation of the

trees will now be extended with a view to the production of bark for British users.

Indian Kapok

As reported at the last meeting of the Committee, official tests of machine-cleaned Indian kapok were carried out by the Board of Trade in order to determine its suitability for use in life-jackets. These tests gave satisfactory results, and the question of the conditions under which the use of clean Indian kapok for life-jackets might be permitted is being considered by the Board. The Imperial Institute has made suggestions with regard to suitable conditions.

Wool Fat from South Africa

In continuation of the investigation of crude wool fat manufactured in South Africa, which was referred to at the last meeting, a trial consignment of about two tons of the material was forwarded to the Imperial Institute for sale. This consignment was disposed of at the market price of £50 per ton, to a firm of manufacturing chemists, who have reported that it is equal to the crude wool fat produced in the United Kingdom, and quite suitable for the preparation of lanolin for pharmaceutical purposes. They have offered to purchase a further consignment of five tons.

(*b*) New Subjects

Tobaccos from East Africa, Nigeria and Cyprus

In connection with efforts to extend the cultivation of tobacco within the Empire, samples of tobacco from the above-mentioned countries have recently been examined at the Imperial Institute.

(1) Samples of American varieties of tobacco from East Africa were of promising character, and would be quite suitable for the United Kingdom market. Enquiry is being made as to the possibility of growing these tobaccos on a commercial scale.

(2) The Nigerian tobaccos, also of American types, were not so good as those from East Africa, but would no doubt be saleable in the United Kingdom. The extension

of tobacco cultivation in Nigeria is under consideration, and it was suggested at the Committee that the natives should be encouraged to grow the crop, with advice from the Agricultural Department, and that the merchants should undertake the curing. In view of the large imports of tobacco into Nigeria for local use it will be some time before export could be undertaken.

(3) The Cyprus tobacco was of Turkish type, and would be suitable for blending with other Turkish tobaccos. A small consignment of the tobacco was sold by the Imperial Institute to London manufacturers at the price of 11*s.* per lb.

Cinnamon Bark and Oil from the Gold Coast

The cinnamon tree has been introduced into the Gold Coast, and is being cultivated experimentally at the Agricultural Stations in the Colony. Samples of the bark from three of the Stations were forwarded for examination at the Imperial Institute and were found to be of very good quality, giving a high yield of oil which contained a large percentage of cinnamic aldehyde. In both these respects the barks were superior to Ceylon cinnamon bark and oil.

The cultivation of cinnamon bark in the Gold Coast on a commercial scale therefore appears to be worth consideration.

Minerals from South Africa

Large quantities of asbestos, mica and corundum occur in the Transvaal, and it is desired by the Department of Mines and Industries in the Union to interest British firms in the development of the deposits, which are at present only partially worked.

(1) *Asbestos.*—The Transvaal asbestos is yellowish, and the fibres measure up to 13 inches in length. This variety of asbestos has hitherto not been regarded favourably by English users, though it is stated that American buyers have offered to take 500 tons per month for five years at a price of £55 per ton. The samples previously sent to the Imperial Institute were rather weak and brittle, but it is stated that material of much better quality is now

being obtained from lower depths of the deposits. The Imperial Institute has asked for representative samples of the improved product for submission to British users.

One mine at Penge is reported to be capable of producing 1,000 tons per month at a conservative estimate, while another mine near Pietersburg could produce 500 tons and increase its production rapidly. It is stated that the asbestos can be put on the rail at Penge for £7 10s. per ton.

(2) *Mica.*—An extensive deposit of mica occurs on the Delagoa Bay–Selati Line, 18 miles south of Leydsdorp, but so far it has only been exploited by people without capital and without special knowledge, and no suitable market has been obtained. The mica is of excellent quality and was accepted for contracts by the American Naval Authorities.

Mica sheets can be obtained up to 36 by 12 inches. At present there is a large amount of waste produced by the crude methods of preparation, much of which could be avoided.

(3) *Corundum.*—Corundum occurs freely in the neighbourhood of Bandolierkop in the Pietersburg District, where there is an area not less than 100 miles long by 50 miles wide, over which the mineral is found in the alluvial rubble.

This corundum is obtained by the farmers, who pay the natives so much a basket for collecting it. It is stated that before the war a German agent entered into a contract with a firm at Mannheim to supply 500 tons per month for five years. During the war a total output of over 500 tons a month was secured, and was shipped principally to England. The mineral could be delivered profitably on the railway at a price of about £5 per ton.

Sheffield Lime

The Imperial Institute has been approached recently by the Birmingham Chamber of Commerce with regard to a difficulty which has arisen in connection with the polishing of non-ferrous metals in the local industries. For this

purpose "Sheffield Lime" is almost exclusively used at present, but the supply has recently been inadequate, and it is consequently desired to find an efficient substitute. It is stated that for many years experiments have been made locally with a view to discovering such a substitute, but without success.

The question is being investigated at the Imperial Institute.

Indian Lac and Lac Substitutes

In view of the present high price of Indian shellac, several enquiries have been received at the Imperial Institute as to the possibility of utilising some of the synthetic resins in place of shellac for particular purposes. It is stated that one American Gramophone Company is now making record discs without shellac, and this procedure is also being considered by another large company, whose representative called recently at the Imperial Institute on his way to India to enquire into the question of future supplies and prices of lac.

From enquiries made by the Imperial Institute it would appear that several firms in this country are making synthetic resins, some of which can be used as substitutes for shellac for certain purposes. It seems probable that the use of these products will extend owing to the almost prohibitive price of Indian shellac.

Intestinal Skins of Whales

Specimens of the intestinal skins of whales have recently been submitted to the Imperial Institute with a view to ascertaining whether they can be utilised for commercial purposes. Previous experiments with these skins for the production of leather have not given very promising results, but the question is now being further considered and technical trials arranged for.

Further information relating to any of the raw materials mentioned in this statement may be obtained from the Director, Imperial Institute, London, S.W.7.

NOTES

Coal: Imperial Institute Monograph.—A monograph on Coal in the series of Imperial Institute *Monographs on Mineral Resources*, by Mr. J. H. Ronaldson, M.I.M.E., M.Inst.M.M., F.G.S., has been published by Mr. John Murray.

The book, of 166 pages, is divided into two chapters, in the first of which is given some interesting historical matter. In the same chapter are various tables giving respectively: a classification of coals; the annual coal production of the principal coal-producing countries of the world for various years since 1865; the consumption, exports and imports of coal for various countries in the year 1913; an estimate of the actual and probable coal reserves of the British Empire; another estimate of reserves, treated continentally, British and Foreign totals being contrasted; and two diagrams showing graphically the increasing outputs of coal in the chief producing countries since 1865.

The second chapter, which occupies the greater part of the monograph, deals entirely with the coal resources of British countries, including lignite or brown coal. It is illustrated by twelve specially-drawn maps, on which all important occurrences are shown, and includes accounts of all the principal occurrences in the British Isles; North Borneo; Federated Malay States; India; Nyasaland; Rhodesia; South Africa; Nigeria; Canada; Newfoundland; and Australasia. In all sections of the chapter the geology of the deposits is fully dealt with, and the qualities and quantities of coals available are indicated.

An appendix dealing with calorific value and evaporative power follows the text, and a bibliography of 167 references at the end of the book forms a useful compendium of recent literature on coal.

The book gives an up-to-date account of the coal supplies of the Empire and will be of particular service at the present time, when consideration is being given to the full utilisation of fuels of all kinds.

Cotton Research Board of Egypt.—In view of the great importance of the cotton growing industry to the welfare and prosperity of Egypt, the Egyptian Government has from time to time appointed commissions to study and report on special problems connected with the crop. It has been increasingly realised, however, that a permanent organisation is needed to conduct research on all matters

relating to cotton cultivation, and a Cotton Research Board was therefore constituted in May 1919 " to combine, co-ordinate and extend research of cotton." On appointing this Board, the Ministry of Agriculture pointed out that " it is of the greatest economic importance to Egypt that every possible step should be taken to maintain the quality of cotton produced in Egypt, so that she may not be displaced from the position of the grower of the best and therefore most valuable cotton of the world," and that " it is of the greatest importance to Egypt to maintain the quantity of cotton which can be grown from each feddan of land. This may be increased or reduced by good or bad cultivation, use of good or bad seed, good or bad methods of watering, and by successful efforts to fight the pests of cotton, such as the cotton worm and boll worm."

The Board will receive assistance from the officials of the Ministry of Agriculture and of the State Domains Administration, and, in addition, a staff of scientific workers is being appointed, consisting of botanists, entomologists, chemists and physicists, who will work in close co-operation with one another.

The Board has recently issued a *Preliminary Report* (Cairo : Government Press, 1920) giving a brief account of its objects and the work hitherto accomplished.

One of its first duties was the provision of suitable laboratory accommodation, and it was decided to erect a building for the purpose at Giza. The plans (which are included in the *Report*) were prepared by the State Buildings Department, and it was hoped that the building would be ready for occupation by June 1920.

Field experiments have already been undertaken by the Board in a number of different localities on (1) the effect of the sub-soil water-level on cotton, (2) reducing watering, (3) yielding power of nine varieties of cotton, and (4) spacing.

The following programme of work has been drawn up :

(1) *Botanical.*—The application of plant-breeding methods to the purification of existing commercial varieties, and to the production of new and improved varieties. Cotton seed farms are being developed for the multiplication of pure seed strains. The physiological aspects of the problems connected with plant breeding will come under study as soon as a plant physiologist has been appointed. The mycologist will make a study of fungoid diseases and especially of cotton wilt.

(2) *Entomological.*—The study of the life-history, distribution and control of *Oxycarenus hyalinipennis* (cotton

seed bug) and *Agrotis ypsilon* (cut-worm). A report on the control of the pink boll worm (*Gelechia gossypiella*) by one of the entomologists attached to the Ministry of Agriculture has been submitted to the Board, who have made various suggestions regarding it ; the study of this pest is being continued.

(3) *Chemical.*—Observations in connection with manures and sub-soil water. A study of the bacteriology of Egyptian soil. The chemical investigations arising out of the composition of cotton seed and the changes which occur during storage.

(4) *Physical.*—The physicist will be mainly occupied with the field experiments. In addition he will do a good deal of laboratory work on the measurements of length, strength, diameter, uniformity, etc., of cotton fibre. He will also be engaged on the statistical work resulting from the field experiments.

Arrangements have been made for the formation of a library, and for the publication of the results of the research work carried out by the Board.

The *Report* gives a short account of the present position of the cotton crop in Egypt, and includes tables showing (1) the areas under cotton and the production in each of the years 1894–1918, and (2) the production in each of the years 1820–1893. It is pointed out that, although there is still a slight tendency towards extension of the area, it is evident that the limits of cotton cultivation under existing irrigation facilities have been nearly attained (cf. this BULLETIN, 1919, **17**, 196). During the war the area devoted to cotton underwent considerable reduction, and there was also a marked decline in the average yield per feddan. The latter is mainly attributable to the ravages of the pink boll worm.

A diagram is given which brings out the striking fact that from September 1919 to January 1920 it was more profitable to the grower to cultivate the shorter-stapled cottons of the Upper Egypt class, such as Ashmouni, than the longer-stapled varieties, such as Sakellaridis. This was due to the premium on the latter being insufficient to compensate for the higher yield given by cottons of the Ashmouni type. In consequence a tendency has arisen for cultivators in Lower Egypt to substitute Upper Egyptian and other comparatively short-stapled cottons for Sakellaridis, and there is a danger that this action will extend greatly unless purchasers are prepared to offer a substantially higher price for the longer-stapled kinds.

A bibliography of publications, issued since 1900, bearing on cotton research in Egypt is appended to the *Report.*

Wheat Growing in South Africa.—For a number of years the production of wheat and wheat flour in the Union of South Africa has seldom exceeded 60 per cent. of the requirements, and the deficit has been made up by importation, chiefly from Australia, Canada and Argentina. Before the war the failure of this agricultural country to become self-supporting in the most important and one of the most adaptable of food crops was not regarded as a matter of sufficient gravity to justify the adoption of any special measures. Owing to shipping difficulties on the entry of the United States into the war, following some months of unrestricted submarine warfare, the country suffered almost a complete severance of its export and import trade. Urgent measures to meet the essential food requirements of the people were then rendered necessary; the Wheat Conservation Act, imposing restrictions on the milling, mixing and disposal of flour by the South African millers, requiring the conversion of imported flour into Government regulation flour, and fixing maximum prices for conversion, was passed by the Union Parliament, and in March 1918 the Minister of Agriculture appointed a Departmental Committee "to enquire into and report upon wheat growing in the Union, and to give such information and advice thereon as may be helpful to wheat growers, especially with a view to securing an increase in the production of wheat at an early date."

High market prices for wheat stimulated home production, and abundant supplies of suitable substitutes enabled conservation to be easily accomplished. At the beginning of 1919 there was a large carry over of the 1917–18 crop in the millers' stocks, and, with the cessation of hostilities in November 1918, difficulties in obtaining supplies elsewhere began to disappear. The *Report* of the Departmental Committee which has been published recently is consequently almost entirely occupied with an economic investigation into the problems of wheat growing under normal conditions, and their relation to the whole farming systems in the wheat-growing regions.

The *Report* contains a detailed analysis of the factors affecting wheat production in each of the following areas: (1) South-west Cape. (2) South and south-east coast. (3) Namaqualand. (4) Southern Border Karoo. (5) Main Karoo. (6) North-east Cape and East Griqualand. (7) Eastern High Veld of the Orange Free State and Transvaal. (8) Main Transvaal. (9) Natal. (10) Basutoland. The principal conclusions reached are:

(1) Wheat cannot be grown in South Africa in competition with the chief wheat-exporting countries without the

protection afforded by cost of transport and either or both the preferential railway rates and the duty on wheat and flour now in force. In normal times the quantity imported will depend on market price and whether other crops are remunerative to South African farmers, though if necessary the country can produce considerably more than the present demands of the population.

(2) Wheat is the most important of all the autumn- or winter-sown cereal crops ; it ranks second to maize in value of production among all farm crops, but will never occupy the primary place. It cannot be grown successfully as a summer crop owing to climatic conditions and liability of the crop to rust, and is confined mainly to areas of winter rainfall, *i.e.* South-west Cape and some of the adjoining coastal districts where rust is not too severe, to Namaqualand, and to the irrigated lands, chiefly those under permanent irrigation and remote from the railway.

(3) The exploitation of the chief producing area (South-west Cape) has nearly reached its zenith. Namaqualand is capable of producing a considerable quantity, but owing to low productivity increase will be of slow growth. Increase in production may be expected as development takes place in bringing land under irrigation.

(4) Improved yields will be obtained by the more extensive use of varieties best suited to the district, better cultivation, improved farming methods and the greater use of fertilisers wisely applied.

The Committee consider that if a rust-resisting variety could be procured, production along the coastal belt would be enormously increased, and they recommend provision being made for further research. Whilst recognising the pressing need for the self-contained experiment station desired by wheat growers in these parts of the Union, they suggest that on grounds of expense the work should be restricted for the present to the testing of suitable varieties throughout the coastal districts. They add that some immunity from rust attack may be secured by the use of dry farming methods and by growing the durum variety.

There are about 120 varieties of wheat in South Africa and the general cultivation of improved varieties is to be found only in the South-west Cape. Purity of seed is rarely encountered. The impurities and the mixing of varieties have been proved to be caused by volunteer plants from previous crops and the itinerant thrashing machine. A register for seed wheat has been initiated by the Committee, and the Department of Agriculture are endeavouring to spread the use of improved varieties and pure seed.

The work of the Department in this and other directions

is considerably hampered, owing to the number of qualified officers being inadequate to satisfy the increasing demands from farmers. In order to meet the South African farmer's natural but sound conservatism, practical demonstration must be the keynote of his agricultural education, and for this reason the Committee recommend the continuance of the present practice, under which the limited services available are devoted largely to encouraging and extending experimental work amongst farmers under a policy of co-operation with their association. Farmers are accordingly urged to support farmers' associations, so that they may obtain the best services which can be provided.

Two of the most important problems confronting South African agriculture are deficiency of labour and of transport. Whilst offering no opinion as to the causes of, or the remedies for, the deficiency in the supply of farm labour, the Committee consider that the question warrants immediately a separate and thorough investigation. The summary of evidence in the appendixes to the *Report* shows a general consensus of opinion among the farmers that black labour is moving rapidly to the towns, not only on account of the higher wages offered, but owing to the attractions of town life and the opportunities for the education of native children.

In several regions claims for a railway were warmly pressed; and although the Committee anticipated that in some areas a large expansion in production would soon result from a railway extension, they were of opinion that the scope of their enquiry did not permit of presenting any of the claims to the railway administration. They point out that, inasmuch as railroad construction for any region should be based, not on production per square mile, but on productivity per square mile, farmers who have been attracted to, or persuaded to remain in, districts remote from the railway by the low price of land have no claims for the railway, until the turn of their area comes round in order of regional productivity.

Few South African wheats are self-contained as regards milling properties, and the lack of a hard or strong wheat of the Manitoba type for blending is felt greatly by the millers; nevertheless inland millers are stated to have succeeded commercially in producing a flour of fair strength and good colour and flavour. The Committee observe that the milling quality of South African wheat is deteriorating, and that it is now on the average inferior to Australian. The millers complain of its lack of uniformity and dirty condition, and are pressing for the standardisation on the basis of grades, and for the regulation of the market

by exchanges in order to secure an improvement in quality.

The following tables indicate (1) the importance of wheat in comparison with other cereal crops in the Union before and during the war, and (2) the increase in wheat production in the various states during recent years.

(1) *Yield of Principal Cereals in 1,000 lb.*

	Wheat.	Barley.	Oats.	Rye.	Kaffir Corn.	Maize.
Census of 1911 .	362,063	61,145	309,138	40,541	309,545	1,726,503
Year, July 1917 to June 1918 .	608,971	98,572	344,800	49,844	360,283	2,528,018

(2) *Wheat Production,* 1904 1918, *in* 1,000 *lb.*

Year.		Cape of Good Hope.	Natal.	Transvaal.	Orange Free State.	Total Union.
1904	General Census	113,453	493	15,076	12,717	141,739
1908	. . . .	—	—	—	—	207,000
1911	General Census	261,001	1,446	53,098	46,518	362,063
1917	Crop Estimate .	—	—	—	—	468,000
1917-18	Census of Agriculture . .	496,342	849	48,627	63,153	608,971

Statistics showing the position of South Africa in relation to the principal wheat-producing countries will be found in the article on " The Future of Wheat Production with special Reference to the Empire " in this BULLETIN (1919, **17**, 218).

It is satisfactory to note that the Departmental Committee are of opinion that should there be a repetition of the conditions created by the recent war, no danger in respect of shortage of wheat supply in South Africa need be apprehended, provided that farmers are stimulated to grow wheat in preference to other crops by means of either high market prices or State aid. The deficiency in such essential requirements as implements (chiefly ploughs and self-binders) and fertilisers became alarming during the season preceding the close of hostilities, and the Committee urge the importance of early action being taken to ensure supplies reaching the Union if ever a similar position threatens in the future.

The Caa-ehe Plant as a Sweetening Agent.—A sample of the Paraguayan plant, " caa-ehe," was received recently at the Imperial Institute with a request for information as to the possibility of cultivating it within the Empire. The plant occurs along the base of the Amambay hills in North-eastern Paraguay, where it is used by the natives as a sweetening agent. It is found in a rich black, sandy soil, never more than a hundred yards from running water or swamp, and is very sensitive to cold. It is not very abundant, the plants occurring either singly or in groups

of three or four amongst a long grass known as "ypagaré." The district where it is found is somewhat remote, and the cost of collection consequently very high. Attempts have been made to cultivate the plant in Paraguay, but according to Jimenez (*Revista de la Escuela de Comercio*, 1917, **3**, 633; abstr. in *Intern. Rev. Sci. and Pract. of Agric.*, 1917, **8**, 1224) the plant does not grow easily from cuttings, and as a rule it is not reproduced from seed. Certain varieties of the plant, however, are said to reproduce from seed, and it may, therefore, be possible by selection to obtain a fertile variety for cultivation. Bertoni, who has devoted considerable attention to the plant, states that multiplication by division of the stalk is comparatively easy, and that it can also be propagated by cuttings and suckers (*Anales Cientificos Paraguayos*, January 1918; abstr. in *Agric. News*, 1918, **17**, 213).

Caa-ehe is a herbaceous perennial belonging to the natural order Compositæ, and was described in 1899 by Bertoni under the name *Eupatorium Rebaudianum*; it was subsequently referred to another genus under the name *Stevia Rebaudiana* (Bert.) Hemsl., by which it is now known.

When attention was first called to the remarkably sweet character of this plant, it was suggested that the plant might become a serious competitor of sugar, but if it is ever used at all on a commercial scale, it would probably only find a market as a substitute for saccharin as a sweetening agent for use in diabetes, etc. The sweet constituent is a glucoside, first termed eupatorin, but later named estevin in order to distinguish it from a toxic bitter substance occurring in *Eupatorium perfoliatum*, to which the name eupatorin had previously been applied. Estevin is stated to be accompanied in the plant by another sweet constituent which has been named rebaudin, and is regarded as probably consisting of a compound of estevin with potassium and sodium. Estevin and rebaudin are said to be respectively 150 and 180 times as sweet as cane sugar. The plant also contains a wax, resin, fatty oil and a bitter principle, which are present in the crude sweet principle extracted from the plant. The bitter principle, which causes a bitter after-taste, can be easily separated from the glucoside. According to Rasenack (*Chem. Centralb.*, 1908 (2), p. 78), the leaves contain 20·26 per cent. of the sweet principle, whilst Dieterich (*Chem. Centralb.*, 1909 (2), p. 459) obtained 1·6 per cent. from entire plants. The latter investigator has expressed the opinion that the glucoside could not be profitably extracted on a commercial scale, and that the only feasible way of utilising the material

would be to employ the powdered leaves as a sweetening agent. The leaves contain a much larger percentage of the glucoside than the other parts of the plant, but they form only a comparatively small proportion of the whole plant. It is stated that the leaves if dried may be preserved for an indefinite period without deterioration.

A plantation of caa-ehe has been established in Paraguay by Señor Jimenez, who, according to the Department of Overseas Trade, is stated to be in a position to supply plants ready packed to stand a long journey. It would be interesting if the plant could be cultivated experimentally on a small scale in some of the tropical parts of the Empire, but from the data at present available it seems doubtful whether either the leaves or the glucoside could compete as a sweetening agent with saccharin, except possibly for local use.

New Petroleum Law in Colombia.—The new law on hydrocarbon deposits by the Colombia Congress on December 30, 1919, is known as Law 120, and consists of 45 articles. By Art. 2 the territory is divided into three zones: (1) deposits 200 kilometres or less from the seashore, which pay an exploitation tax of 10 per cent. of the raw product; (2) deposits above 200 km. and up to 400 km., which pay 8 per cent.; and (3) deposits more than 400 km., which pay 6 per cent. This tax is a minimum tax upon the raw product in each zone, and for every ten years of exploitation there will be an increase of 1 per cent. on such minimum. By Art. 3 deposits situated on unappropriated lands belonging to the nation will pay a further tax of \$0·10, \$0·20, \$0·50 and \$1 (*peso*) per hectare of the concession in the first, second, third and fourth years, respectively, until the expiration of the lease, but lands adjudicated or ceded as unappropriated of later date than October 28, 1873, will only pay the exploitation tax of Art. 2. By Art. 4, private lands pay an exploitation tax of 8, 6 and 4 per cent. of the raw product, in zones (1) (2) and (3) respectively.

Art. 6 is of importance to foreigners, as those interested in the winning of petroleum, etc., must declare expressly that they submit themselves to Law 145 of 1888, relating to naturalisation. By Art. 12, a Government licence must be obtained for the exploration of uncultivated lands that are not appropriatable. By Art. 13 an exploration licence is also necessary for lands appropriated after October 28, 1873, but the owners must be notified first, and may claim compensation for any damage caused by such exploration. Art. 15 states the way in which the

application for a lease-contract is to be made out—*e.g.* the zone applied for must be from 1,000 to 5,000 hectares in area; plans must be submitted; and the name and nationality of each applicant must be given. By Art. 17, when there are several applications, preference will be given to the discoverer, or, failing such, to those persons who give the best guarantees for fulfilling the contract, winning the deposit, etc. Owners of the soil on lands appropriated later than October 28, 1873, and before Law 30 of 1903, will have the preference as regards lease-contracts for the term of two years from December 30 last. By Art. 20, before granting any contract, the Ministry will publish in the *Diario Oficial* an extract therefrom, indicating the area, rent, etc.; and when ninety days have expired after such publication, the authorisation of the contract may be given. By Art. 21, the ministerial authorisation having been given, it must be submitted to the Exchequer Board, created by Law 109 of 1919, and to the Council of Ministers, and the contract with the person chosen by the joint Board and Council will then be drawn out. Art. 23 deals with the terms of the contract; *e.g.* the contract shall be for twenty years, and can be extended for a further term of ten years, at the option of the Government; the Government reserves to itself the right of watching over the undertaking, from technical, fiscal and economical points of view; at the termination of the contract, or, when under forfeiture or lapse (see Art. 29), any plant or other installations on the concession revert to the Government without process of law; the cash guarantee or security shall not be less than $20,000 (*pesos*). By Art. 24, no single individual may acquire more than 3 zones of 5,000 hectares each. By Art. 25, the Government reserve the right to supervise the exploitation, and to fix the minimum of production in each case. By Art. 27, any technical or economical data, asked for by the Government, must be freely given, pupils of the Government schools must be admitted to the works, and Colombian workmen must be employed in the proportion of not less than 50 per cent. of the total number of hands employed. By Art. 28, deposits on lands distinct from those mentioned in Art. 3 must not be exploited within sixty days' previous notification to the Government, and, within one year of the actual commencement of the winning, plans, reports, etc., must be submitted. Failing notification, the tax will be doubled for a term of not less than one year, and other penalties may be enforced.

By Art. 29, a lease-contract shall be deemed to have lapsed or to have become void, (1) when it is transferred to foreign governments, or when they are admitted as

shareholders ; (2) when the Government right of watching over the undertaking (see Art. 23) is wilfully obstructed ; (3) when the rent and taxes are not paid punctually or in full ; and (4) when, after five years from the date of the concession, the deposits are not ready for continuous exploitation, or when the workings have been suspended for a whole year. By Art. 30, the tax may be paid in kind or in money, at the option of the Government. By Art. 34, if paid in kind, 30 per cent. belongs to the department, 5 per cent. to the municipality, and the remainder to the nation—the division to be made half-yearly. By Art. 35, all plant, pipe-line, etc., are exempt from every class of import or duty. By Art. 37, two zones, one along the boundary with Panama, and the other along the boundary with Ecuador, are reserved for geological study by the Government, and are subject, among other things, to a special tax of 20 per cent. of the raw product. By Art. 38, the nation reserves to itself the right of working below the territorial sea, lakes and navigable rivers, and any contracts for such workings must have the approval of Congress. By Art. 45, the Nation reserves to itself the winning of radio-active substances.

According to the *Petroleum World* of June 1920 (vol. xvii., p. 232), Colombian capitalists are at last preparing to take an active part in oil matters generally. A company called the *Compañia Colombiana de Petroleos* has recently been formed with a capital of $1,000,000 (*pesos*), among other objects to safeguard small owners of oil-bearing properties ; and the *Compañia de Fomento* has been formed with an initial capital of $100,000 (*pesos*), which may be eventually increased to $10,000,000 (*pesos*), to develop the oil regions, etc. Some of the most influential Colombians in the Republic are among the original shareholders. In the same number of the *Petroleum World* (p. 244) there is an article on the oil fields of Venezuela and Colombia, compiled by Messrs. Geo. A. Huhn & Sons of New York and Philadelphia, and a map is published showing the various bore-holes that have been put down for oil in both countries, which, in the near future, may take " an important place in the table of the world's petroleum production."

A copy of the new Colombian petroleum law, and a full translation, may be consulted in the Library of the Imperial Institute.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the BULLETIN *a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India and the Tropics generally. It must be understood that the Imperial Institute accepts no responsibility for the opinions expressed in the papers and reports summarised*

AGRICULTURE

FOODSTUFFS AND FODDERS

Sugar.—A special committee of the Ceylon Agricultural Society has presented a report recommending the establishment of sugar cultivation in the island (*Board of Trade Journal*, 1919, **103**, 623). The report points out that there are immense possibilities for sugar production in Ceylon, both from the cane and the palmyra palm; and in order to prevent a repetition of the heavy losses that accompanied the private enterprise of the past in this direction, it is desirable that Government aid be secured in the form of land concessions, loans and experimental work in the initial stages. It is recommended that two sets of pans of an improved type be erected in Jaffna and in the Central, Western, or Southern Provinces, and an improved mill and set of pans in the Kalupahana cane-growing area, and that experimental cultivation of cane under tank irrigation be undertaken in the dry zone with the object of securing reliable figures for future work. Attention is drawn to the fact that the peasants along the banks of the Gingana are used to the cultivation of sugar cane, and with a view to reviving the industry in this district the Government is invited to examine the possibility of erecting a small modern mill on a suitable site.

Rice.—In *Bulletin* 783, 1919, *U.S. Dept. Agric.*, an account is given of the life-history of the rice moth, its ravages, and measures for its destruction. This pest has only been known in the United States since 1911, and was identified in 1916 as *Corcyra cephalonica*, Staint. It is inclined to be omnivorous, since it breeds in rice, dried fruits, cocoa, chocolate, ship biscuits and sesame seeds. It produces copious and dense external webbing to which food materials, such as rice and cocoa, strongly adhere. Destruction by means of steam or fumigation with hydrocyanic acid or carbon disulphide is recommended.

Avocado Pears.—An article published in the *Bull. Dept. Agric. Trinidad and Tobago* (1919, **18**, 113) reviews the history of this fruit in the West Indies and its distribution throughout the world, and deals with the selection of varieties, propagation and cultivation. Further articles in the same *Bulletin* deal with the advantages of budding and methods of performing it, insects affecting the avocado in Trinidad and Tobago and methods for their control, the fungoid diseases of the fruit and remedial measures, and the composition of the Trinidad avocado. Comparative analyses are given showing the amount of oil contained in the Trinidad fruit to be only half that of the Californian fruit, viz. 23·7 per cent. as against 46·0 per cent., expressed on the dry pulp, of which the Trinidad avocado yields somewhat less than the Californian fruit.

Sunflower Silage.—With a view to the selection of a suitable crop, more or less resistant to drought, that will yield a heavy tonnage of green material per acre for silage purposes, the Idaho Experiment Station grew a trial plot of two acres of sunflowers which were cut in the early part of September 1918 and made into silage. The crop, however, did not fill the silo, and ten days elapsed before maize was added in sufficient quantity to fill the silo entirely. Samples of silage were taken in January at the depth of 2, 6 and 9 feet from the top of the sunflower silage and its content of acids determined. The first sample was dark in colour and had a disagreeable odour, while the second was much better in appearance, but showed the presence of butyric acid. Sample 3, however, at a depth of 9 feet, showed an acid fermentation similar to that found in good maize silage. The abnormal fermentation of samples 1 and 2 is considered to be due to air permeating the silage in the period that elapsed before filling up the silo with maize, thus favouring the growth of organisms responsible for the abnormal fermentation. Sample 3, however, showed that under proper conditions an excellent grade of silage can be produced. An analysis of samples showed the composition of sunflower silage to compare favourably with that of maize silage. Feeding trials indicated that sunflower silage was equal to maize silage for many purposes and appeared to offer a good substitute for the latter in districts where maize cannot be grown (*Journ. Agric. Research*, 1919, **18**, 325).

Oils and Oil Seeds

Castor Seed.—Investigations have been undertaken to ascertain which variety of castor seed is most suitable for

cultivation in South France, and at the same time to establish the botanical characteristics of the various plants raised therefrom (*Les Matières Grasses*, 1919, **12**, 5159). Experiments were carried out at Marseilles with different varieties of seed, obtained from Morocco, Senegal, Indo-China, Madagascar, India, Martinique and Brazil. Of twenty-three varieties sown, most produced plants, although only twelve developed into plants that matured well. The best results were yielded by the seeds from Senegal and India, which in every case gave plants that matured. Varying success attended the trials with the seed from the other sources. Descriptions of the different plants raised are included in the article.

Coconuts.—The pests affecting the coconut palms of the Zanzibar Protectorate are discussed in the *Bulletin of Entomological Research* (1920, **10**, 145). Rhinoceros beetles (*Oryctes monoceros* and *O. boas*) are common throughout the country, and are by far the most serious pests. Young trees about three years old are most commonly attacked, many being killed and others greatly delayed in reaching maturity. Trees in isolated positions and on bad soil are very liable to become affected, though fully mature ones harbour the adult beetles, but are not seriously damaged. It has been found that the most useful method of control is to trap the larvæ in pits filled with rotting coconut trunks, vegetable débris and a little manure. Reference is made to the mammals which destroy these beetles, and a list of the minor pests is also given.

Investigations are to be carried out by the Department of Agriculture, Fiji, with regard to the small leaf moth (*Levuana iridescens*) (*Bulletin* 12, 1919, *Dept. Agric., Fiji*). The larvæ of this moth feed on the coconut leaflets, moving along in tracks parallel to the veins, and eating away the lower epidermis and the chlorophyll cells, the leaves consequently becoming brownish-white. The effect of this pest upon the coconut palms is practically the same as that of defoliation, namely, a low yield of fruit. The attacks of the moth are, at present, chiefly confined to the Island of Vitilevu. The objects of the investigations are to ascertain the distribution of the pest at all periods of the year in various districts; to determine the relation between the prevalence of the pest and the climatic variation, and between the direction in which the pest travels and the prevailing winds; and to discover the best methods of control. It is considered impracticable to control this pest artificially by the use of sprays, whilst smoking cannot

be regarded as a remedy. The use of traps has not yet been fully investigated (cf. this BULLETIN, 1918, **16**, 108).

According to Reinking (*Philippine Journal of Science*, 1919, **14**, 131) "bud-rot" disease of coconut palms is caused by *Phytophthora faberi*, Maubl., the organism which produces black rot and canker of cocoa, fruit rot and canker of Hevea rubber, and rot of papaya fruit. The disease is most abundant in very humid sections, and in thickly planted groves. Reinking recommends that, as infected trees never recover, they should be cut down and all the infected parts burned. Clean cultivation should be practised in all groves, and coconuts ought under no circumstances to be interplanted with cocoa or papaya. Trees in new groves should be planted 10 metres apart each way. A paper on the same subject by Merino is published in the *Philippine Agricultural Review* (1919, **12**, 91.)

Ground Nuts.—An account of the ground-nut trade of China is given in the *Board of Trade Journal* (1920, **104**, 161). Previous to 1914, the bulk of the exports went to Europe, particularly to France, but during the war this trade was diverted to the United States and Japan. The exports of kernels and oil in 1918 were as follows:

To	Kernels.	Oil.
	Tons.	*Tons.*
United States .	320	14,420
France . .	235	514
Japan. . .	20,920	13,974
Other countries .	7,525	6,239
Total . .	29,000	35,147

During this period the United Kingdom received no shipments of either kernels or oil. Formerly the oil was shipped to Shanghai, Canton and Hong Kong, but now it is being largely sent to Dairen and Japan for reshipment. The trade with Japan and the United States has become so great that a Japanese Company has equipped a special fleet of ships for the transport, and special wharves with storage tanks have been fitted at Seattle in the United States. Tsingtao, which only exported 8,757 tons of oil in 1913, has become the principal point for the collection of ground-nut oil for export. Several Japanese firms have erected power presses for expressing the oil in the vicinity of this port; but usually the oil is extracted at the places of production. Shantung is the largest ground-nut producing district in China, and it is estimated that it yields about 223,000 tons of nuts every year.

Miscellaneous.—The possibility of the commercial utilisation of tomato and grape seed is discussed in the *Journ. Indust. Eng. Chem.* (1919, **11**, 1134). These seeds, mixed with skins, are waste products from the tomato pulping stations and the grape juice plants. A method for the separation of the wet tomato seed from the waste has been operated on a factory scale and for grape seed on a semi-commercial scale. As the different stations do not produce enough seed to warrant the erection of oil-presses at each one, it is suggested that the seed after separation should be sent to a Central Factory where the oil would be expressed, after the seed had been washed free from adhering refuse and dried in rotary driers. Tomato-seed and grape-seed oils have been successfully refined, deodorised and made into edible products (cf. this BULLETIN, 1918, **16**, 254). Experiments on animals have demonstrated the feeding value of the residues. Estimates are given for the cost of working a process on these lines, from which it would appear that tomato seed and grape seed from the waste of the canning industry can be profitably utilised for the production of oil.

It is considered that Morocco might become a large producer of oil seeds, as it possesses a rich and fertile soil (*Les Matières Grasses*, 1919, **12**, 5287). The oil would be more profitably expressed in Morocco, where labour is cheap, than if the seeds were exported to France for this purpose. The oil cake might be used locally for the feeding of the large herds of cattle that are reared by the natives. Coconuts, palm nuts, ground nuts, castor seed, soy beans and sesame seed are included among the oil seeds that it is suggested might be grown.

The Government of Senegal have been investigating the question of the industrial utilisation of "sump," the oil seeds of *Balanites aegyptiaca* (*L'Agron. Col.*, 1919–20, **4**, No. 26, p. 42). It is stated that 5,000–6,000 tons a year of these seeds could be obtained. The fruit consists of outer skin and pulp, 43 per cent.; nut shell, 48 per cent.; and kernel, 9 per cent. The pulp contains 40 per cent. of sugar, and it is suggested that it might be used for the manufacture of alcohol. The kernels yield 41·8 per cent. of oil, which corresponds to 7·6 per cent. in the nut and 3·7 per cent. in the whole fruit. The constants of the oil are stated to be nearly identical with those of cotton-seed oil, and it might be employed for the same purposes in industry. The extraction of the kernels from the nuts is difficult as the shell is very hard; mechanical decortication has not yet been tried. It is concluded from these investigations that the commercial exploitation of the fruits of *Balanites*

aegyptiaca is, at present, not to be advocated. A report on an investigation at the Imperial Institute of the fruits and oil of *B. aegyptiaca* received from Nigeria, Sudan and Uganda is given in this BULLETIN (1908, **6**, 364).

The results of the examination of "betratra" seeds, *Jatropha mahafalensis*, Jum., from Madagascar are published in *Bull. de L'Agence Général des Colonies* (1919, **12**, No. 143, p. 679). The seeds consist of kernels, 81·4 per cent., and shell, 18·6 per cent. The shell is thin and difficult to separate from the kernels to which it adheres. The oil cake is stated to be toxic, and therefore unsuitable for cattle. The whole seeds yield by extraction 44·6 per cent. and by pressing 40 per cent. of oil. The constants of the oil are: acid value, 4·0; saponification value, 188·4; iodine value, 107·4; Reichert-Meissl value, 0·6. No alkaloids or cyanogenetic glucosides were found in the seeds. The oil is considered suitable for soap-making. It is recommended that cultivation trials be carried out in those parts of Madagascar which have a dry climate (cf. this BULLETIN, 1911, **9**, 62).

A list of the most important trees cultivated in Tonkin which produce oil seeds of economic interest is given in *Bull. Econ. Indo-Chine* (1919, **22**, 520). Among these are included *Sapium sebiferum, Aleurites moluccana, Bassia Pasquieri*, and *Camellia Sasanqua*. It is suggested that their cultivation should be encouraged among the native population with a view to the exportation of the oil seeds.

RUBBER

Hevea

Insect Pests.—According to *Archief voor Rubbercultuur* (1919, **3**, 437) a white grub (*Holotrichia leucophthalma*, Wied.) has caused damage in Java, similar to that recorded by Green some years ago in the case of the grubs of *Lepidiota pinguis* in Ceylon, where some thousands of Hevea stumps on a clearing were killed, the rootlets being eaten and the tap-roots decorticated. These are stated to be the only cases known of white grubs attacking Hevea plants. The life cycle of *Holotrichia leucophthalma* takes one year. The grub leaves the egg after twenty-five to twenty-nine days, and after about eight months the pupa stage is reached, from which after twenty-seven to thirty-four days the beetle emerges. The beetles were found flying in Java during the months October to January, this being the commencement of the wet season. In order to combat this pest, it is recommended to remove decaying stumps, leaves, branches, etc.,

from new clearings before the flying season commences, and to leave soft weeds as trap plants on a clearing which is infested with Holotrichia, since the latter prefer such weeds to Hevea plants.

Preparation of Rubber.—Experiments on the effect of soaking the rolled or unrolled coagulum in water on the properties of the rubber are recorded in *Archief voor Rubbercultuur* (1919, **3**, 369). It is shown that in the first place an extraction of serum substances takes place, causing a loss in weight in the dry rubber and a decrease in the rate of cure. The loss amounts to 0·2 to 0·4 per cent. for crêpe, 0·5 to 3 per cent. for sheet and 0·2 to 2 per cent. for unrolled coagulum, according to the hardness of the coagulum and the duration and intensity of the water treatment. On further soaking in water, viz. for from twenty-four to forty-eight hours, the rubber matures, causing a further loss in weight, whilst the rate of cure increases, and the original retardation diminishes or changes into an acceleration. The accelerators formed by the maturation do not appear to be extracted by the water, or at the most only partially, and are formed in spite of the fact that a considerable part of the serum substances has been removed by the water in the initial stages. The experimental data show that the viscosity decreases at the same time as the rate of cure, but in a much smaller degree, while the changes in tensile strength and slope are small. Soaking in water for five to twenty hours proved to be an effective method for the prevention of mouldiness.

Chrysil Rubber

A report recently published by the University of California, entitled "A Rubber Plant Survey of Western North America" (*Publications in Botany*, 1919, **7**, No. 6, pp. 159–181) records the results of a systematic search for rubber-bearing plants of possible economic value in California, Nevada, Oregon, Utah and Colorado. Rubber was found in two closely related genera of shrubs, *Chrysothamnus* and *Haplopappus*, belonging to the natural order Compositæ. Of the former the most important species is *C. nauseosus*, of which twelve varieties were examined and rubber found in all of them, although individual plants were occasionally devoid of rubber. This was the only source of rubber occurring in sufficient quantity to be interesting, and for this particular kind of rubber the name Chrysil has been adopted. Although *Haplopappus* spp. yield more rubber than *C. nauseosus*, *i.e.* 6 to 10

per cent., the rubber is soft and resinous, and considered of little importance.

C. nauseosus is a large shrub, growing readily from seed and reaching maturity in from six to eight years. The rubber, which is stated to be of high grade, somewhat below best fine Para, but far superior to most African wild rubbers, vulcanises without difficulty. The latex does not occur in continuous tubes like those of Hevea and other trees, which can be tapped, but in isolated cells, as in the case of guayule. Altogether 180 analyses are tabulated, which show an average of 2·83 per cent. of rubber in the variety *hololeucus*, 2·69 per cent. in var. *pinifolius*, 2·52 per cent. in var. *viridulus*, 1·97 per cent. in var. *consimilis*, and lower percentages in other varieties, which are comparatively uncommon. The varieties enumerated occur most abundantly in Colorado, Nevada and Utah. The rubber occurs in the stem in greatest amount at about the soil line, whilst in the root it is present only in the upper portion ; young twigs and leaves contain only small amounts. The richest tissues are the cortex and, to a lesser degree, the medullary rays. In harvesting the wild shrub the whole plant is taken, including four inches of root, and the bulk reduced by removing the twigs, whilst in the case of cultivated plants it is suggested that the base of the stem should be left for further growth. The cultural requirements of *Chrysothamnus* are such that it could be grown without irrigation in many of the alkaline plains of Western North America. It has been found that the best-yielding varieties of *C. nauseosus* are those which inhabit alkaline soils. Certain varieties endure a winter temperature of —20° F., whilst others withstand summer temperatures obtaining anywhere in the western states with the possible exception of the hottest valleys.

In addition to the account of Chrysil the report contains a key to the varieties of *C. nauseosus*, an account of various species of *Haplopappus* and a list of sixty-four plants of various families which were found to contain no rubber. The report points to the desirability of continuing the investigation of *Chrysothamnus* with a view to making the cultivation a commercial success.

Fibres

Cotton

Sudan.—In *Sudan Notes and Records* (1920, **3**, 12) an interesting article on Tokar is contributed by G. J. Fleming. Tokar is a small delta of about 300,000–400,000 acres situated between the Red Sea and the hills running parallel

to it. It has been formed by the action of the Baraka khor, which rises in Erythrea and is joined by several other khors, including the Ambucta from Abyssinia and the Langeb from the Sudan. After emerging from the hills, the Baraka begins to spread out until its possible breadth may be upwards of thirty miles ; it flows intermittently during July, August and September, and may water an area of 50,000–120,000 acres. The average annual rainfall of the Tokar district does not exceed 6½ inches, and the Baraka flood occurs several months before the rains commence. The cotton crop is therefore usually independent of rain, although there is no doubt that rain at the right season is of great benefit. The flood of 1918 was a light one and watered an area of about 40,000 acres, but as very little rain fell, the crops were almost a failure. The waters of the flood deposit their silt and quickly subside.

If the cotton is sown too early on the watered land, the seedlings may be destroyed by the violent south winds which sometimes arise. The cotton is also liable to be washed out by a late flood, but resowing is readily accomplished as the large amount of moisture in the ground enables the seed to germinate easily.

The seed is specially selected from the best cotton passing through the Tokar market, and is purchased by the Government and distributed to growers at cost price. It is sown on the flat in irregular rows. No tillage is required, as a good mulch is naturally spread over the ground in the form of silt. The sowing is effected by making holes in the silt with a stick, and throwing a few seeds in each hole and covering them up. The young plants appear above the ground in three or four days. If the plants escape destruction by the south winds or by the attack of locusts, the crop is usually sufficiently advanced by February to enable enough cotton to be picked daily to warrant the opening of the cotton market. The number of people in Tokar during February and March is at least 20,000, whereas in July the population may dwindle to 2,000–3,000. A large proportion of those present at the picking season are West African pilgrims on tour to or from Mecca. As the cotton is gathered it is put into sacks and taken straight from the field to the market. The market is under Government control, and experts from Alexandria are engaged to grade the cotton before it is exposed for sale. The cotton is sold by auction, each grade being sold separately. It is then baled and the grade is stamped on the bale by Government. The bales are transported by camels from Tokar to Trinkitat, a distance of nineteen miles, and are then loaded into small local craft

termed "sambuks" which convey them to Suakin or Port Sudan.

Cotton was first introduced into Tokar between 1850 and 1860 by Ahmed Mumtaz, a Turkish Pasha, who was then Governor of Suakin. The industry was interrupted during the Dervish rule, and no real progress took place until 1900, when the present Government began to take an interest in the crop. At the present time, the small Baraka delta is the most important cotton-growing centre in the Sudan.

The possibilities of further development in the Tokar district depend on (1) the volume of the Baraka flood, (2) the supply of labour, and (3) the climatic conditions. The regulation of the flood by artificial means would obviate the waste of large quantities of water, and would doubtless prove of great benefit. The work would entail great expense, but nevertheless the question is being carefully considered. The difficulty with regard to labour is accentuated by the exodus of a large part of the population in May, when the climatic conditions become very unpleasant. This could be remedied by means of a railway, the extension of which to Tokar is now under consideration. The climatic conditions unfortunately cannot be altered and will always be a drawback to cotton growing in Tokar, and as far as can be seen at present they will continue to be the chief limiting factor.

Nyasaland.—It was shown in an article on "Cotton Growing in Nyasaland" (this BULLETIN, 1919, **17**, 237) that up to 1916 the cotton industry of the Protectorate had made steady progress, the maximum exports being nearly 3,500,000 lb. in the year mentioned. During the last year or two, however, the industry has undergone a serious decline, owing partly to the compulsory cultivation of foodstuffs for military supplies, but chiefly to the dissatisfaction of the European planters in the Highlands with the small yields obtained. An account of the industry, given in the *Ann. Rep. Dept. Agric., Nyasaland Protectorate*, 1918–19, shows that the position has become very grave. The European acreage fell from 28,372 acres in 1917–18 to 18,141 acres in 1918–19, and the production from 4,448 bales of 400 lb. each to 1,911 bales. The yield per acre also declined, that in Mlanje being only 12·3 lb., in Blantyre 18 lb., and in the Ruo district, which gave the best average results, 84 lb. Moreover, the cotton produced was of poorer quality than usual. The planters variously attribute these unfortunate results to the deterioration of the cotton plant, to a repetition of unsatisfactory

climatic conditions, to the lack of manuring, and to the cultivation of cotton repeatedly on the same land instead of in a rotation of crops. The acreage under European cultivation and the total yield of lint in the different districts were as follows :

District.	acres.	cwts.
Lower Shire	520	267
Ruo	4,487	3,353
West Shire	2,760	1,312
Blantyre	6,555	847
Mlanje	200	22
Zomba	2,945	836
Upper Shire	534	119
South Nyasa	140	71
Total	18,141	6,827

The native cotton crop fell from 1,070 tons of seed-cotton in 1917 to only 365 tons. This was due to the continued demand for native labour for military purposes, and the necessity of growing foodstuffs in view of the famine conditions which prevailed throughout the year. The actual yields of seed-cotton in the various districts were approximately as follows : Lower Shire, 57 tons ; Ruo, 155 tons ; West Shire, 104 tons ; Mlanje, 27 tons ; Upper Shire, 22 tons.

Nigeria. Southern Provinces.—In the *Ann. Rep. Agric. Dept., Southern Provinces, Nigeria*, 1918, it is stated that in 1918 the quantity of cotton available for export was much less than usual. This was due to unfavourable climatic conditions, and to an increased demand for cotton for local use owing to the high prices of imported cotton cloth. Seed-cotton was purchased to the amount of 3,599,136 lb., from which 2,621 bales, each of 400 lb., were obtained. Considerable progress in cotton growing was made in the Ogbomosho district in consequence of the establishment of a buying station by the British Cotton Growing Association, and the discovery by the natives that they received a better price for their seed-cotton at this station than they had previously obtained from native middlemen.

In the Meko district, arrangements were made for Georgia cotton to be grown instead of the native variety. This cotton is much superior to the native kinds, and is now well acclimatised. It also has the advantage of being a quick-growing variety, a feature which is of considerable importance in connection with the control of insect pests, and it is being propagated as rapidly as possible for general distribution. In 1918, 12 tons of Georgia cotton seed were

distributed in the Meko district, and smaller quantities in the Oyo and Iseyin districts.

Much damage is caused to the crop in the Southern Provinces by cotton stainers. Throughout the cotton season, gangs of small boys were employed in picking off these insects by hand, but in spite of these efforts one-third of the crop was graded as stained cotton. It is pointed out that if growers would destroy the cotton plants at the close of the picking season, the suppression of cotton stainers and other pests would be greatly facilitated.

FORESTRY AND FOREST PRODUCTS

Afforestation in Zululand.—The results obtained by the Natal Government since 1904 in a plantation at Empangeni in Zululand are described by Mr. J. S. Henkel, formerly the Conservator of Forests (*Rhodesia Agric. Journ.*, 1920, **17**, 50). Exposed to strong salt-laden south-east winds, with a rainfall of about 40 inches, principally in the summer, and poor soil, the indigenous vegetation consisted mainly of scattered and stunted acacias. Conifers mostly proved unsuccessful, with the exception of *Araucaria Cookii* from New Caledonia, seed of which is difficult to obtain. Eucalypts were most successful, nine species making good growth when close planted (10 feet × 10 feet) ; and the results on 700 acres induced the Union Government to embark upon a larger scheme on 10,000 acres between the Umhlatusi and Umlalusi Rivers, rather nearer to the port of Durban, with which there is railway communication.

Afforestation in New Zealand.—In the *Report* on afforestation for 1915 it was computed that the native timber reserves of New Zealand were being depleted at the rate of 24,000 acres yearly, against which less than 2,000 acres had been afforested, *i.e.* less than one-fourteenth of the area deforested, or more precisely the figures are 32,645 acres afforested in twenty years as against 480,000 acres deforested. The afforestation hitherto carried out by the Lands Department has consisted of artificial plantations at low altitudes. In two papers on the subject communicated to the New Zealand Institute Science Congress at Christchurch in February 1919 (*New Zealand Journ. of Science*, 1919, **2**, 339) the authors are agreed that exotic species—pines, poplars and eucalypts—are best calculated to yield quick returns of milling timber, the moist equable climate, even in mountain areas, producing an annual growth greatly exceeding that of their native countries.

Mr. W. G. Morrison, the author of one of these papers, advocates natural afforestation by the planting of a few mother trees of Scots, cluster and Monterey pines, and English oak, on land not suitable for profitable pastoral utilisation at altitudes above 2,500 feet. He supports his suggestion by a description of what has taken place on the Hanmer Plains during the last half-century. Two generations of wind-sown trees of the above-named species of pine have spread to leeward of a few mother trees producing thousands of seedlings per acre, in some cases two miles from the parent trees, on country heavily grazed and infested with rabbits and hares. Mr. Morrison advocates planting at the higher elevations where fencing would be unnecessary, sheep, rabbits and hares being not more than a tenth of the number present in the areas now spontaneously reafforested. Since little or no expense need be incurred for preparation of seed-bed, tending, or fire-prevention, he urges that his proposal presents an extremely cheap method of checking erosion, conserving the water-supply, preventing floods and providing a valuable wind-screen and a supply of timber and turpentine in a not very distant future.

TIMBERS

Burmese Timbers supplied to the War Fronts.—It was not until 1917 that the Government of India were asked to supply timber to our armies in the field. What was done in Burma in response to this request is detailed in an appendix to the *Rept. Forest Admin. in Burma*, 1917–18. Over 72,000 tons were despatched overseas, mainly from Rangoon, to Mesopotamia (nearly 50 per cent.) and Egypt (33 per cent.). Much of it was teak for wharves and railway work, with some padouk (*Pterocarpus indicus* and *P. macrocarpus*) for ordnance work ; sleepers of in (*Dipterocarpus tuberculatus*), pyinkado (*Xylia dolabriformis*), taukkyan (*Terminalia tomentosa*), pyinma (*Lagerstroemia Flos-reginae*), ingyin (*Pentacme suavis*) and other hardwoods ; squares, scantling and planks of these and some twenty other species ; and two species of bamboos (*Dendrocalamus strictus*, Myin-wa, and *Bambusa arundinacea*, Kyakat-wa). Much of the teak and in was in spars up to 60 feet in length for piles, and the squares and heavy planks were demanded in lengths of 20, 25, 30 or more feet. The taukkyan was found to split badly, even when seasoned in the round for a year ; and the heartwood of pyinkado and kanyin (*Dipterocarpus* sp.) remained sound a year after felling, although the sapwood had become rotten.

Sal (*Shorea robusta*).—The mechanical strength and seasoning properties of Sal are dealt with by Mr. R. S. Pearson, F.L.S., Economist at the Forest Research Institute, Dehra Dun, in the *Indian Forest Records* (1919, **7**, 120), in completion of the enquiry described in the *Indian Forest Memoirs* for 1913 noticed in this BULLETIN (1914, **12**, 144). For transverse strain the results are approximately 7 tons per square inch, timber felled in December "when the sap was down" being stronger than that felled in September "at the end of the growing period," or in June, at the commencement of that period. Compression tests applied parallel to the grain gave confirmatory results in this respect, and an average compression strength of 4 tons per square inch. Sal from the United Provinces is slightly stronger than that from the Central Provinces; but in the latter there is no difference between the timber of the plains and that of the hills. Shearing tests parallel to the grain give similar results with a resistance of 0·9 tons per square inch. Hardness tests, calculated on the number of pounds required to press a steel semi-sphere of 0·444 inch diameter completely into the wood, show that sal is exceptional in being harder on the radial and tangential surfaces than on the cross section. As compared with other timbers it is 1,800 lb. against 1,200 to 1,400 lb. in teak, 1,450 lb. in *Shorea assamica* (makai), and 3,000 lb. in *S. obtusa* (thitya). If, therefore, teak is classed as moderately hard, sal is hard and thitya very hard. Sal dries very slowly, readily reabsorbing moisture, especially during the monsoon, and developing star-shakes and surface cracks following the interlocked grain, during seasoning. The best method of seasoning is shown to be under a thatched roof for seven years in the log, followed by conversion and a further seasoning of the scantlings for fifteen months under cover.

Hollong (*Dipterocarpus pilosus*, Roxburgh).—This timber, known as "dulia" in Bengali, and confused with other species as "garjan" at Chittagong, "in" or "eng" in Prome and "kanyin" in the Mu Division of Burma, is fully described from the economic point of view by Mr. Pearson (*Ind. Forest Bulletin*, No. 39, 1919), a mounted specimen of the wood accompanying the report. The tree grows on well-drained slopes at moderate elevations in the rich deep soil of moist evergreen forest, sometimes gregariously or associated with makai (*Shorea assamica*), nahor (*Mesua ferrea*), or in (*Dipterocarpus tuberculatus*), valuable woods which could be extracted together at a great saving of cost. It is extremely tall, commonly

reaching 100 feet with 4 feet girth, and a clear cylindrical bole of 40 to 60 feet. The wood is light red, resembling baywood, but with a pretty silver grain and a not unattractive sheen, and is easy to plane, though not so readily sawn owing to its resinous character. It weighs 43 lb. per cubic foot, and is only moderately hard, but of fair strength and suitable for constructional work under cover, either as beams or planks. It is not durable in the open unless painted or treated with an antiseptic, but can be very readily creosoted. It does not split or warp excessively, but is somewhat slow in seasoning. There is little doubt that the timber would command a ready market in Bengal, especially as creosoted sleepers; but the difficult and unhealthy country in Assam in which it grows, the almost continuous rainfall and the absence of labour make its exploitation a difficult problem.

Wood-paving in India.—From an abstract of experimental records from Rangoon, Calcutta and Bombay (*Ind. Forester*, 1920, **46**, 28) it appears that the contrasting climate of the wet and dry seasons at the two first-named places makes wood-paving unsuitable. Teak, pyinkado and padouk were tried at Rangoon; sal, creosoted Douglas fir and other woods at Calcutta. At Bombay, teak and jamba (*Xylia xylocarpa*) laid down in March 1916 were in perfect condition in 1919. Trial is being made of jamba cut green and not creosoted.

White Cedar (*Dysoxylum* spp.) **for Oil Casks.**—A very large business is done in Cochin in shipping coconut-oil to Europe. It is exported in large casks or "pipes," 6 feet long and 3 feet in diameter at the top, with 30 to 35 staves. According to an account of a recent visit to a cooper's yard (*Ind. Forester*, 1920, **46**, 65), it is essential that the wood used for these casks shall not discolour the oil, and shall not allow it to percolate through the pores, and the so-called white cedars, the meliaceous *Dysoxylum glandulosum* and *D. malabaricum*, are the only woods locally available which answer these requirements. The staves are "flagged" or packed with plantain fibre and dowelled with bamboo pegs, and small leakages are stopped with the same materials. The writer of the report (Mr. C. E. C. Cox, I.F.S.) recommends that some attention should be paid to the species of *Dysoxylum* with a view to their conservation. Gamble states that *D. glandulosum* "is said to be suited for tea-chests, cigar-boxes and similar purposes."

NOTICES OF RECENT LITERATURE

Profit and Sport in British East Africa. By Capt. The Lord Cranworth, M.C. Pp. xvi + 503, Med. 8vo. With Maps and Illustrations. (London: Macmillan and Co., Ltd., 1920.) Price 21*s*. net.

In 1912 Lord Cranworth published the first edition of this work, under the title of *A Colony in the Making*, or *Sport and Profit in British East Africa*, which was, as was pointed out in the Bulletin at the time, an excellent book. It then comprised 359 pages and had one map. He has now reissued it, having transposed the main and secondary titles, added four chapters, a map of German East Africa, a coloured frontispiece after J. G. Millais and other new illustrations. There is considerable inconvenience to booksellers and librarians in such changes of title; but it cannot be denied that the new name is more definitely indicative of the nature of the book than was the old one. Of the four additional chapters, the first is a brief history of the British East Africa Protectorate, with which certainly every settler should make himself acquainted; another gives a history of the recent campaign in East Africa; and a third deals most practically with various new agricultural possibilities such as citrus and other fruits, beans, sugar-cane, coconuts, etc. That which is, perhaps, the most interesting to the business man at home is Chapter XII, which gives us the first full account of the young flax-producing industry in East Africa, its methods and its prospects. Lord Cranworth recognises that this crop can probably not be worked profitably on less than 1,500 acres, which would necessitate a capital of £12,000; and he, therefore, suggests a co-operative plantation and factory. At the time the book was published—only a few months ago—the main difficulty in promoting this or any similar industry in the Protectorate was the scarcity of effective labour, owing to our heavy native losses during the war. The pulling, retting and scutching of flax require under existing circumstances a large proportion of somewhat skilled labour if the due amount of high-grade fibre with the smallest proportion of tow is to be obtained; but already the invention is announced of labour-saving machinery suitable for colonial use for all these processes of flax-preparation.

With these useful additions to the already valuable series of chapters on African races, health, agriculture, forests, minerals, administration and sport, including Lady Cranworth's practical hints to women settlers, the author has given us a first-rate compendium of sound advice,

which every intending colonist will do well to obtain, read and treasure, and which in its present enlarged form cannot be said to have been unduly enhanced in price.

Flax Culture and Preparation. By Fred Bradbury. Pp. xii + 154, with 91 illustrations, Demy 8vo. (London: Sir Isaac Pitman & Sons, Ltd.). Price 9*s.* net.

In view of the developments which are taking place in East Africa, Canada and other parts of the Empire in connection with flax growing, a need has arisen for a textbook giving a complete account of the operations involved in this industry. This want has now been supplied by the present volume, which will doubtless prove of great service both to growers in the United Kingdom and also to planters overseas.

The author of the book, who is Professor of Textile Industries at the Municipal Textile Institute, Belfast, has given careful study, both theoretical and practical, to the various problems connected with the production and utilisation of flax. The work gives a full account of flax cultivation and preparation, and deals with all stages of the industry from the selection and examination of the seed intended for sowing to the marketing of the scutched fibre. The questions of soil and climate, the preparation and manuring of the land and the methods of sowing and harvesting are discussed, and the processes of rippling or deseeding, retting, breaking and scutching are fully described with the aid of numerous excellent illustrations.

The book is written in a clear and interesting manner and includes all the more modern developments of the subject, such as the pulling of flax by machinery and the artificial retting methods. It will doubtless prove helpful, not only to flax growers and scutchers, but to all who are interested in the fibre and in the spinning, weaving and distribution of linen materials.

Identification of the Economic Woods of the United States. Including a discussion of the Structural and Physical Properties of Wood. By Samuel J. Record, M.A., M.F. Professor of Forest Products, Yale University. Second Edition, revised and enlarged. Pp. ix + 157, Med. 8vo. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1919.) Price 8*s.* 6*d.* net.

The detailed study of wood structure has in general one of three objects: either it is biological or physiological, being directed to the elucidation of the mechanism of tree life; or it is comparative and intended to identify and

discriminate between woods, which can then be classified for purposes of reference; or it is economic, endeavouring to trace the relation between the structure and the various uses to which woods are put. Though restricted to the woods of the United States, Professor Record's two volumes have, by their thorough and lucid analysis of wood structures from all three of these points of view, become classics, and all students of wood will examine with the greatest anticipatory interest a second edition of one of them. The author has, as we should have expected, found little to correct or alter in his general account of the structural and physical properties of wood, so that the first half of the original work appears almost unchanged. In order presumably to avoid the expense of resetting Part I, twenty pages of valuable new matter, mostly histological, but including twelve tables of American woods with reference mainly to such structural characters, are somewhat regrettably relegated to an Appendix. Part II, however, the classificatory key to the useful woods of the United States, has been entirely recast with the happiest results. Professor Record has now taken gross characters of general similarity as the chief bases of his grouping so as to contrast woods most likely to be confused. Microscopic characters appear in smaller type than those recognisable by the naked eye. Such a key, as the author recognises, is always subject to revision with increasing data and the comparison of more species, its object being practical utility in identification rather than an arrangement in accordance with true affinities. Some suggestions as to the methods of preparing and examining specimens might well have been given. The plates are the same as in the first edition; and, considering that there are in all some forty pages of additional matter, while all the costs of production have much increased, the rise of price, from 5*s.* 6*d.* in 1912 to 8*s.* 6*d.* now, cannot be called exorbitant.

FOREST PRODUCTS: THEIR MANUFACTURE AND USE, EMBRACING THE PRINCIPAL COMMERCIAL FEATURES IN THE PRODUCTION, MANUFACTURE AND UTILISATION OF THE MOST IMPORTANT FOREST PRODUCTS OTHER THAN LUMBER, IN THE UNITED STATES. By Nelson Courlandt Brown, B.A., M.F., Professor of Forest Utilisation at Syracuse University. Pp. xix + 471, Med. 8vo. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1919.) Price 21*s.* net.

Though scientific principles are of universal application, their practical use is so modified by local conditions as to necessitate special treatment in every country.

Thus, though the principles of vegetable physiology, and those of forestry, which are mainly derived from them, have been worked out in Europe, no mere translation of such works as Gayer's *Forstbenutzung*, or Mathey's *Traité d'exploitation commerciale des bois* would be adequate for use in America, India or Australia, and every country which essays a scientific treatment of its forests finds itself compelled to produce its own practical handbooks. Professor Brown in the present work seems to have filled a gap in our textbooks of American forestry very efficiently. His treatment of the existing technological methods in the production of wood-pulp, veneers, slack and tight cooperage, turpentine, charcoal, wood-distillates, sleepers, roof-shingles, maple sugar, excelsior, etc., is excellent, giving in most cases the history of the industry in America, the requirements and sources of the raw material, a summary of the existing methods of treatment and of the utilisation of the products, with some illustrative statistics and a select bibliography for each section. As he says in his Preface, " A book could easily be written on each subject " ; but since he seems to have felt the inconvenience of the restricted space at his disposal, it seems to us that he would have done well to confine himself to American technology, omitting altogether such exotic topics as rubber, cork and those dyeing and tanning materials with the production of which his students are not likely to be concerned. On the other hand, it would be very useful for the foreign reader if a short glossary could be added of such terms as " stumpage," " bolt," " shook," " shake," and even " lumber," the precise meaning of which is not always clear. We doubt if any of the process-block illustrations add at all to the practical utility of the book, while they have necessitated the use of a heavily clayed paper which brings the weight of the volume up to nearly $2\frac{3}{4}$ lb.

Forest Management. By A. B. Recknagel, B.A., M.F., and John Bentley Jr., B.S., M.F. Pp. xiii + 269, Med. 8vo. (New York: John Wiley & Sons; London: Chapman & Hall, 1919.) Price 12*s*. 6*d*. net.

The authors, both professors in the faculty of forestry at Cornell, have set themselves the difficult task of preparing an intermediate textbook, not so elementary as to assume no knowledge of the subject on the part of the reader, nor so technical as to be beyond the capacity of the undergraduate or the non-professional timber owner. American forestry has become so specialised that the work contains few references to European procedure and Sir

W. Schlich's volume bearing the same title is not even mentioned. The present work, though somewhat shorter, is slightly more comprehensive than the latter since it includes a chapter on the necessary preliminary survey of area, in which the instruments employed should, we think, have been described, and a concluding chapter on forest administration. In the subdivision of their subject-matter the authors seem to have adopted a strictly logical basis, though some more illuminating title than "Forest Organisation" is wanted for that department of it which deals with rotation, the regulation of the cut and the formation of the working-plan, a department for which Sir W. Schlich can only suggest the cumbrous "Foundations of Forest Management." The treatment of the subject is thorough but concise, space being saved by the omission of detailed working of mathematical examples such as are given in Sir W. Schlich's work. The two books are to a great extent complementary, though the more recent one touches on several topics nót dealt with in the earlier, e.g. the preliminary survey of a forest area, the appraisal of damages to forest property, and administration. The Cornell handbook is by no means easy reading; and, though absolutely indispensable to the American student, can, owing to the widely different conditions, only interest those on this side of the Atlantic who are concerned in the comparative study of the higher methods of forest administration.

Botany for Agricultural Students. By John C. Martin, Professor of Botany at the Iowa State College of Agriculture and Mechanic Arts. Pp. x + 585, Med. 8vo. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1910.) Price 12*s*. 6*d*. net.

There are abundant signs that the American "practical" man, especially when concerned with the cultivation of the soil, has far more appreciation of the value of scientific training than has his English compeer. He maintains numerous agricultural bureaux, colleges and schools, each furnished with a considerable staff of specialists. Just, however, as we often see in business matters a haste to "get rich quick," so in education there seems too often to be a hankering after speedy royal roads to omniscience, or at least to that comprehensive knowledge of great width which is inevitably of little depth. Professor Martin states in his preface that his book is intended for elementary courses of one year's duration in colleges and universities, and explains his presentation of the reproductive structures and processes of flowering plants before that of

the vegetative organs as adopted to suit the time of year at which the scholastic year begins for his classes. This is only one instance of a lamentable lack of logical sequence or division which marks the whole book, though it must be admitted that the various chapters are accurate popular sketches of their various topics and that the author says that they "have been written so as to be separately understandable" and "adaptable to any arrangement of topics that the teacher may prefer." The body of the work is divided into nearly equal parts: "Plants (Chiefly Seed Plants) as to Structures and Functions" and "Plants as to Kinds, Relationships, Evolution, and Heredity." The first of these, but for the unusual arrangement above mentioned, seems to us an admirable, though necessarily brief, summary of the general anatomy and physiology of spermatophytes. Many agricultural plants such as maize, oats, beans, etc., are employed as illustrative examples, practical topics such as the vitality of seeds and seed analysis are touched upon, as also are such more recent questions as double fertilisation, enzyme action, soil bacteria and root excretion. Part II devotes forty pages to the Algæ, twenty to Liverworts and Mosses and twenty to the Pteridophytes—groups of but little concern to agricultural students—whilst the "Families of Angiosperms of most economic importance," of which twenty-six are mentioned, are all dismissed in about as many pages. A chapter of thirteen pages is then devoted to a sketch of ecology, and the last fifty pages are devoted to evolution (from Erasmus Darwin to De Vries and Weismann), heredity (discussing the views both of Galton and Mendel) and plant-breeding. This appears to us to comprise abundant matter for a course of at least double the duration of that suggested in the preface. There are nearly five hundred excellent illustrations in the text, and the book is strongly and simply bound in a style suitable to the lecture-room and laboratory.

THE MINERALOGY OF THE RARER ELEMENTS. By E. Cahen and W. O. Wootton. 2nd Edition. Revised by E. Cahen. Pp. xxxii + 246, Crown 8vo. (London: Chas. Griffin & Co., Ltd., 1920.) Price 10*s.* 6*d.*

The increasing interest shown in the rarer elements and their compounds is well illustrated by the necessity for producing a second edition of this interesting and useful publication, the first edition of which was noticed in this BULLETIN (1913, **11**, 186). It may be remarked that many of the shortcomings of the earlier edition have been remedied in the present volume.

The minerals are arranged, with certain modifications, according to the classification of Gustav Rose, the descriptions of the minerals being preceded in each case by a very brief account of the properties, commercial uses, methods of extraction and detection of the principal constituent element.

Although in most cases the information given under the heading " commercial uses " is correct, one can hardly pass unchallenged the statements that molybdenum (p. 51), niobium (p. 37) and zirconium carbide (p. 178) are used as filaments for electric lamps, when it is doubtful if such use ever got beyond the experimental stage.

The list of minerals designated as being of commercial importance is still much too large, particularly in the case of those containing titanium, tantalum and uranium.

The chapter on " Geographical Distribution," which is a very useful feature in this edition, has been rewritten and considerably enlarged, but is still capable of further improvement. The occurrence of thorianite in Madagascar is noted, but no mention is made of its having been found in Ceylon, although it is from the latter country that the only commercial supplies of the mineral have been obtained.

The commercially important deposits of uranium ore in Portugal also appear to have escaped notice. India is not mentioned among the countries in which platinum occurs, although for many years past a small output has been recorded.

It is to be regretted that there are so many blank pages in the book. This defect is particularly noticeable in the section on Assaying, in which an attempt is made to deal with the estimation of most of the rarer elements in twenty-five pages, nearly half of which are blank. These vacant spaces might well have been utilised for the elaboration of the assay methods, which in many cases are too sketchy to be of practical use.

In spite of the above defects, the volume should prove of considerable service to all who have to deal with the ores of the rarer elements principally from a mineralogical standpoint.

MICROSCOPIC EXAMINATION OF THE ORE MINERALS. By W. Myron Davy and C. Mason Farnham. Pp. ix + 154, Med. 8vo. (New York and London: McGraw-Hill Book Co., 1920.) Price 15*s*. net.

This little book covers practically the same ground as Dr. J. Murdoch's *Microscopical Determination of the Opaque Minerals* (reviewed in this BULLETIN, 1917, 15,

145), which it closely resembles in treatment and format. It is a description, with determinative tables, of the art of polishing, identifying and examining the ore minerals under the microscope by reflected light, for which the name "mineragraphy," suggested by W. L. Whitehead, is adopted by the authors in "the hope that something better will be suggested."

The first nineteen pages deal in a practical manner with the technique of polishing and examining the specimen and the photomicrography of polished sections. Given suitable laboratory equipment of diamond saw and rotating laps, the entire process of cutting, grinding and polishing the section need not take more than ten minutes, we are told. The methods of testing hardness sectility and streak, and applying reagents under the microscope are described. Estimates of the electrical conductivity of a mineral and its behaviour under electrolysis may sometimes help in its determination.

The determinative tables form the main part of the book. They are not based primarily on colour, as in Murdoch's book, but on the behaviour of the mineral when touched by a drop of reagent. Six reagents are employed, namely, 50 per cent. solutions of nitric acid and hydrochloric acid, 20 per cent. solutions of potassium cyanide and ferric chloride, and saturated solutions of mercuric chloride and potassium hydroxide. The minor divisions of the tables are based on hardness and colour. Recognising that in the determination of the minerals in an average polished section of ore it is a handicap to restrict the examination to mineragraphic tests alone, the authors give a chapter of supplementary tests, including the ordinary blowpipe tests for the elements.

It is not easy to see what has influenced the authors in their selection of ore minerals. While thirty-nine antimony minerals are described—many of which are rare—no ores of aluminium, magnesium or tantalum are mentioned. Most of the minerals described are opaque, but not all, since cassiterite, rutile and sphalerite are included.

The book should prove a useful aid to students of ore-genesis. In a later edition it is to be hoped that methods of separating, examining and determining mineral grains will be described, as the title of the book would certainly lead one to expect.

Manual of the Chemical Analysis of Rocks. By H. S. Washington. Third edition, revised and enlarged. Pp. xii + 271, Med. 8vo. (New York: John Wiley &

Sons, Inc.; London: Chapman & Hall, Ltd., 1919.) Price 11*s.* 6*d.* net.

The third edition of this well-known work will appeal to all chemists interested in accurate analytical methods. In general the methods described are those which have been adopted for the examination of rocks by the United States Geological Survey and described in their *Bulletin* No. 422, but little or no comparison is made between these and alternative methods. The present volume, however, gives much more consideration than the *Bulletin* to manipulative details and is therefore of greater value to the less experienced chemist.

After descriptions of suitable apparatus and its use, the selection and preparation of the rock samples are considered, and sources of operative errors are fully discussed. This section occupies about two-fifths of the book and is followed by detailed descriptions of the methods recommended for the determination of the chemical constituents of rocks. In the appendixes are given (1) some useful factors for conversion and (2) an example of the method of calculating the results of an analysis for a basaltic lava. The value of the work is enhanced by numerous references to original investigations.

This book can be recommended to all mineral analysts who desire to obtain results of great accuracy, but it is hardly suitable for those who only wish to make rapid and approximate estimations of a single ore constituent.

CEMENT. By Bertram Blount, F.I.C., assisted by W. H. Woodcock and H. J. Gillett. Pp. xii + 284, Demy 8vo. *Monographs on Industrial Chemistry.* (London: Longmans, Green & Co., 1920.) Price 18*s.* net.

In this volume the authors have confined their attention almost entirely to Portland cement as understood according to the British Standard specification and have not considered seriously the manufacture and properties of other cements used in building, such as natural cement, hydraulic lime and Keene's cement.

After a brief historical survey of the subject the raw materials are discusssed and numerous analyses of material from different localities are quoted. The following chapter on "Manufacture" deals with the preparation of the raw materials and their conversion into cement and includes a good account of one of the most up-to-date labour-saving plants in this country. Some authorities will not agree with the author's statement on page 59 that "to put it shortly, the fixed kiln is dead," as many hold that for the dry process of manufacture the latest

type of continuous fixed kiln can compete with the rotary kiln on practically equal terms.

The power required on a cement works is briefly considered in Chapter V, whilst the succeeding chapter deals with "Works Control," chiefly from the chemical aspect. This chapter gives useful indications as to the extent to which the stores, and both raw and manufactured products, should be analysed.

The physical testing and chemical analysis of the finished cement are considered in Chapters VII and VIII, the former consisting largely of a reprint (with comments) of the British Standard Specification. The concluding chapters deal with the chemistry of Portland cement, and its uses and by-products. It is to be regretted that the authors have not given more consideration to the important question of the effect of magnesia on the stability of Portland cement in view of the fact that non-magnesian limestones are somewhat sparsely distributed in certain countries. In this connection valuable information could have been secured from the publications of the United States Bureau of Standards.

In the appendixes are given data likely to be of service to the cement works chemist, together with a number of abstracts and translations of foreign specifications for Portland cement, including those of France, United States, Russia, Italy and Argentina. The section devoted to the last-mentioned specification is headed "Extracts covering the Essential Points in the New Argentine Government Cement Specification," but the extracts have been made from the 1911 specification, and not from that issued in 1914, which supersedes the former and differs from it in several important respects. Each consignment of cement intended for export for use on public works in Argentina must be certified, as complying with the specification, by the laboratories and testing departments controlled by the Ministry or Public Works in the country of origin. In 1915 the Board of Trade arranged that this testing in the United Kingdom should be carried out at the Imperial Institute and a special laboratory was installed in order to conduct such tests as might be required.

The volume is a welcome addition to this well-known series of handbooks on industrial chemistry and should prove of considerable value to all interested in the testing and manufacture of Portland cement. It is well printed, and is illustrated by numerous excellent diagrams. Its value would have been enhanced still further by the inclusion of more references to current literature, which are given in one chapter only.

THE PEAT INDUSTRY REFERENCE BOOK. By F. T. Gissing. Pp. xxiv + 292. (London: Chas. Griffin & Co., Ltd., 1920.) Price 7*s.* 6*d.*

Information relating to recent progress in the utilisation of peat is scattered through many books and periodical publications, and the author has performed a useful service in issuing the present volume, in which much valuable matter has been brought together and carefully summarised. After a brief summary of the composition and well-known properties of peat, methods of working the deposits are described, but it is in the ensuing sections dealing with its utilisation that the most useful matter occurs. Here is considered the use of peat as solid and gaseous fuels, and the utilisation of its distillation products, the descriptions of plant being elucidated by numerous diagrams.

In addition to its uses as fuel, peat has been suggested for many other purposes, *e.g.* as a source of ammonia, and for the manufacture of paper, industrial alcohol, artificial wood, etc., all of which are briefly dealt with. The main problem to be solved in connection with the suggested use of peat as fuel as well as for some other purposes is the removal of the large amount of water it naturally holds, without greatly increasing the cost.

The book can be recommended to all who require a concise and up-to-date summary of information relating to the utilisation of peat.

THE MINING AND MANUFACTURE OF FERTILISING MATERIALS AND THEIR RELATION TO SOILS. By Strauss L. Lloyd, E.M. Pp. vi + 153, Crown 8vo. (New York: D. van Nostrand Company; London: Crosby Lockwood & Son, 1919.) Price 9*s.* net.

This book is stated, in the preface, to be intended for the use of manure manufacturers, farmers and agricultural students, but it is hardly likely to appeal to either the first or last mentioned, whilst such statements as "Almost every soil contains enough Ca, Mg, S, Fe, Si, Cl, and Na for the growth of a full crop" will not be much appreciated by the farmer who has no knowledge of chemistry.

Within the compass of this small volume the author has attempted to discuss the numerous subjects included in the title, and it is therefore unavoidable that in many cases the descriptions are incomplete. As examples it may be mentioned that the various processes for the fixation of atmospheric nitrogen are dismissed in three pages, and the

recovery of potash from seaweed and the conversion of the latter into a manure are given in less than one page.

Some of the chapters contain much elementary matter which might well have been omitted, *e.g.* a detailed statement why 1 lb. of nitrogen would give more than 1 lb. of ammonia. The arrangement of the subject matter in many places is poor; thus Chapter VI, headed "Phosphorus," includes sections on ammonium sulphate, sodium nitrate and potash, and Chapter VII, entitled "Artificial Manure Manufacture," deals only with phosphate manufacture, except that three paragraphs relating to the amounts of phosphate and nitrogen applied as manures are inserted in the middle of a description of the manufacture of superphosphate.

Chapters IV and VIII, dealing with the mining and preparation of rock phosphate, and its conversion into superphosphate, are more satisfactory and contain useful information.

BOOKS RECEIVED

Cocoa and Chocolate: their History from Plantation to Consumer. By Arthur W. Knapp, B.Sc., F.I.C. Pp. xii + 210, Demy 8vo. (London: Chapman & Hall, Ltd., 1920.) Price 12*s.* 6*d.* net.

A Guide to the Identification of our More Useful Timbers: being a Manual for the Use of Students of Forestry. By Herbert Stone. Pp. viii + 52, Demy 8vo. (Cambridge: University Press, 1920.) Price 7*s.* 6*d.* net.

Maps (on Mercator's Projection) having Special Reference to Forest Regions and Geographical Distribution of Timber Trees. No. 1, The World; No. 2, North America; No. 3, South America; No. 4, Europe and Africa (and part of Asia). Prepared by J. Hudson Davies, F.R.H.S. On rollers, mounted on linen, size 40 in. by 30 in. (Edinburgh: W. & A. K. Johnston, Ltd.; London: Macmillan & Co., Ltd.) Price 8*s.* net each.

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Dominion, Colonial and Indian Governments.

THE COMPOSITION AND USES OF AUSTRALIAN *XANTHORRHŒA* RESIN

THE genus *Xanthorrhœa* comprises a number of species of tree-like plants belonging to the lily family, and known under the general name of "grass-trees"; they are found only in Australia. The trunks consist largely of the old leaf-bases in which is deposited a resin, either yellow or red in colour, according to the species. The chief species yielding these resins are: (1) *X. hastilis*, R. Br., of Eastern and South-Eastern Australia, which yields a yellow resin, known commercially as yellow gum acaroid, Botany Bay gum, yellow yacca gum, etc., (2) *X. arborea*, R. Br., of Queensland and New South Wales, (3) *X. australis*, R. Br., of New South Wales, Victoria and Tasmania, (4) *X. Tateana*, F. Muell., of South Australia, and (5) *X. Preissii*, Endl., of South-Western Australia, all of which yield a red resin, known as red gum acaroid, red yacca gum, black-boy gum, etc.

The resins have been used to some extent in the past for making varnish, sealing wax, etc., and before the war some 200–300 tons are stated to have been exported annually from Australia, mainly to Germany. It was demonstrated many years ago that the resin could be used as a source of picric acid, but its use for this purpose was discontinued when phenol became available cheaply from coal tar; but there is some evidence that prior to 1914 Germany had revived the use of yacca gum as a source of picric acid. In this connection it must be remembered that phenol is generally cheaper in England than in

Germany, and consequently it might be feasible to use *Xanthorrhœa* resin in Germany for making picric acid when this would not be economically possible in the United Kingdom. From time to time, vague statements have appeared as to the discovery of new uses for the resin in Germany. Rumours were persistent that it was being used there in the manufacture of high explosives, but enquiries made by the Imperial Institute before the war as to the uses to which it was actually being put in Germany yielded no confirmation of this, and all the evidence collected seemed to indicate that it was being used chiefly for varnish and lacquer manufacture, and as a cheap substitute for shellac.

In the past the collection of the resin has not been conducted in a systematic manner, but concessions for exploiting the black-boy tree of Western Australia have been granted to a syndicate who have also secured the rights to the whole of the grass-trees in Victoria. It seems probable therefore that regular supplies of the resin will be available in the future.

Investigations on the composition and uses of *Xanthorrhœa* resin have been conducted at the Imperial Institute for several years past, and more recently in Australia. The work on the subject at the Imperial Institute has for the present been brought to a close, and a full account of the results obtained has been communicated to the Australian authorities. A summary of these results is given in the following pages.

Examination of the Resin

Preliminary experiments with *Xanthorrhœa* resin were conducted in 1915 with samples of yellow and red resin forwarded from Australia. Both kinds contained woody impurities, the amount in the yellow resin being fairly large. The resins gave the following results on examination :

		Yellow.	Red.
Moisture (in vacuo at ordinary temperature)	*per cent.*	3·0	3·5
Ash	*per cent.*	1·3[1]	0·24
Matter insoluble in alcohol (chiefly woody matter)	*per cent.*	13–14	4
,, ,, ,, ether	*per cent.*	23	16
Melting point (determined on the powdered resin in a capillary tube)		97° C.	110° C.

[1] *Including some sand.*

Lauterer (*Botany Bulletin*, No. XIII, *Queensland Dept. Agric.*, 1896) states that he obtained 9·4 per cent. of benzoic acid from the resin of *X. hastilis* and 5·6 per cent. from that of *X. arborea*; whilst according to the *Perfumery and Essential Oil Record* (1915, **6**, 212), red acaroid resin has been found to contain 4·6 to 7·2 per cent. of benzoic acid. In view of these statements attempts were made to isolate this acid at the Imperial Institute. It was found, however, that in the case of the samples of both the yellow and red resins which were investigated, no appreciable quantity of benzoic was present.

According to Stenhouse (*Journ. Chem. Soc.*, 1845, **3**, 10) the resin on dry distillation yields an oil "which appears to be completely identical" with phenol. Attempts to distil the resin at the Imperial Institute were unsatisfactory, as the resin foamed very strongly and charred. Only small quantities of oily distillate were obtained. This possessed a phenol-like odour, but no definite indication of the presence of phenol was shown by the ferric chloride test.

A more detailed investigation was subsequently conducted with a commercial sample of red *Xanthorrhœa* resin which was subjected to a preliminary purification by extraction with alcohol in order to free it from about 12 per cent. of wood fibre and a small amount of mineral matter which it contained. The work carried out with this material was directed to the determination of (1) the approximate composition of the resin, (2) the effect of fusing the resin with potash, (3) the action of nitric acid on it, (4) the behaviour of the resin with oxidising agents (potassium permanganate, potassium dichromate and chromic acid), (5) the effect of heating the resin in sealed tubes, and (6) the products of its destructive distillation. Only a brief summary of the results obtained can be given here.

I. Composition of the Resin

The approximate composition of the resin purified by extraction with alcohol was as follows, as compared with the results obtained with red resin by Tschirch and Hildebrand (*Arch. Pharm.*, 1896, **234**, 698):

	Per cent.	Results obtained by Tschirch and Hildebrand. Per cent.
p-Coumaric acid in free state	0·5	1·0
,, ,, combined	1·5	2·0
Cinnamic acid	0·1	nil
Styracin	0·1	nil
Aldehydes	—[1]	*p*-Hydroxybenzaldehyde 0·6
Complex phenolic body	The residue	85·0

[1] *Not determined; probably vanillin is present in small quantity, as it was isolated after the oxidation of the resin.*

II. Results of Fusion of the Resin with Potash

The following products were obtained after potash fusion of the resin, compared with those obtained similarly from the *yellow* resin by Hlasiwetz and Barth (*Annalen*, 1866, **139**, 78):

	Per cent. (approximate).	Hlasiwetz and Barth from yellow *Xanthorrhœa* resin. Per cent.
p-Oxybenzoic acid [1]	1·5	13·0
Resorcinol	2·0	1·4
Phenol	0·4	—
Pyrocatechin	not detected	1·8
A double compound of protocatechuic acid and *p*-oxybenzoic acid	not detected	2·3
Carbonic acid	much	—

[1] *It appears that the yield of this acid is dependent largely on the temperature of the fusion and the duration of heating. Earl (Bull. No. 6, Dept. Chem. South Australia) obtained 8 per. cent. of this acid from X. Tateana resin, but, apparently, no resorcinol.*

III. Action of Nitric Acid on the Resin

The products obtained by the action of nitric acid on the resin under different conditions were: picric acid, *p*-nitro-phenol, an amorphous nitro-compound, and oxalic acid.

IV. Action of Oxidising Agents on the Resin

The following products were obtained as the result of the action of oxidising agents on the resin:

(a) *Potassium permanganate.*
Oxalic acid, about 40 per cent.
Acetic acid, small amount.
Carbonic acid, appreciable amount.
Vanillin, about 0·2 per cent.

(b) *Potassium dichromate and chromic acid.*
Principally an insoluble chromium compound.

V. Effect of Heating the Resin in Sealed Tubes

The resin is only slightly affected at a temperature of 150° C., and at higher temperatures undergoes decomposition with the production of products similar to those obtained on destructive distillation.

VI. Destructive Distillation of the Resin

Small-scale experiments gave a yield of about 17 per cent. of an oily distillate of a phenolic nature. The experiments were difficult to carry out, owing to excessive frothing of the melted resin.

Uses of the Resin

A large number of experiments have been carried out at the Imperial Institute on the preparation of picric acid from both the red and the yellow resins, and on the possibility of using them as substitutes for shellac and rosin in the manufacture of lacquer for metals, of spirit varnish for wood, and of sealing wax; dyeing trials with the resins have also been carried out.

Preparation of Picric Acid

As mentioned in the summary given above, picric acid and other substances are produced by the action of nitric acid on *Xanthorrhœa* resin. The results of preliminary experiments indicated that the yellow resin should yield at least 30 per cent. of picric acid and the red resin at least 25 per cent., though on a commercial scale higher yields could probably be obtained.

The feasibility of utilising the resin for the manufacture of picric acid depends on the supply of phenol available, since picric acid can usually be obtained much more cheaply from phenol than from *Xanthorrhœa* resin. Many experiments have been made by experts on high explosives with the resin as a source of picric acid, but apparently in no case has it been found possible to reduce sufficiently the relatively large amount of nitric acid required in its production to make the manufacture of picric acid from *Xanthorrhœa* resin profitable in this country in normal times in competition with phenol.

As a Substitute for Shellac and Rosin

1. *Lacquer for Metals.*—Solutions of the yellow and red resins in methylated spirit (containing 10 per cent. of the resin) were tested both alone and also in admixture with different proportions of shellac, as lacquers for brass and steel. The solutions containing only *Xanthorrhœa* resin gave brilliant coatings, which, however, appeared to be more brittle than shellac ; this defect could probably be remedied by the addition of other ingredients. The solutions of the *Xanthorrhœa* resins in admixture with shellac were more satisfactory. The dark colour of the red resin and its property of darkening still further on heating would prevent its use in light-coloured lacquer, especially where the lacquer is to be stoved, but should be advantageous in cases where a red colour is desired.

Lacquers prepared from *Xanthorrhœa* resin appeared to stand exposure in a dry atmosphere satisfactorily ; they withstood a test of short duration in a moist atmosphere fairly well, but deteriorated rapidly on immersion in water and in this respect compared unfavourably with shellac.

2. *As Spirit Varnish for Wood.*—A 30 per cent. solution of the red resin in methylated spirit gave a fairly lustrous but dark coat on sized wood. The yellow resin gave a similar but lighter-coloured coat.

The *Xanthorrhœa* resin varnish appeared to be less brilliant than rosin (colophony) varnish, but showed better resistance to wear ; it is, however, inferior to shellac varnish in the latter respect. It should be possible to use *Xanthorrhœa* resin alone in cheap varnishes for floors, etc., or in admixture with shellac.

The use of *Xanthorrhœa* resin for the preparation of lacquer or varnish is somewhat limited by the fact that it is insoluble or only partially soluble in turpentine, fatty oils, benzene or petroleum spirit, although soluble in alcohol. The colour of the red resin would also be a disadvantage in certain cases.

3. *Sealing Wax.*—The red and yellow resins and mixtures of these resins with shellac were incorporated with turpentine and chalk to form sealing wax. The wax made from the red resin darkened and decomposed rather readily on heating ; this resin could only be used for very inferior

grades of sealing wax. The yellow resin gave a wax which showed much less tendency to darken on heating, and it might be used either alone or in admixture with shellac.

Dyeing Trials with the Resin

The examination of red and yellow *Xanthorrhœa* resins as possible dyestuffs was undertaken in 1916, when samples of silk and woollen materials stated to have been dyed in Australia with the resin of *X. Tateana* were submitted to the Imperial Institute by the High Commissioner for Australia. These dyed specimens consisted of thirteen small pieces of material ; eleven of them were of wool and varied in tint from bright greenish yellow to fairly dark brown, including shades of buff, and the two remaining samples were of silk. The colours of the samples were found in some cases not to be "fast to soap." No details were given as to the methods of dyeing and mordanting employed in producing these specimens.

No authentic specimen of resin from *X. Tateana* was available for the purpose of dyeing trials at the Imperial Institute, and experiments were therefore made with supplies of ordinary red and yellow *Xanthorrhœa* resins furnished by Australian merchants in London. An exhaustive series of dyeing trials was carried out with both resins, and a fair range of tints, varying from pale yellow to deep brownish-black, was found to be obtainable on wool and silk by the use of suitable mordants ; but the tints were weak in comparison with those given by fustic, especially in the case of the yellow resin. Further disadvantages were that large quantities of the resins had to be used, and that they could only be employed in alkaline solution, which is especially undesirable in the case of wool. Both resins proved quite unsuitable for use on cotton.

In spite of these disadvantages the results of the test seemed sufficiently promising to make it worth while to consult dye-extract manufacturers and dyers in the United Kingdom. The manufacturers were considerably interested in the results obtained, but they did not consider that the resins would be able to compete successfully with the natural dyestuffs already in use in this country, such as fustic, or with synthetic yellow and brown dyes,

with which better results can be obtained at a lower cost. The dyers confirmed this opinion, and considered that the resins could not compete with fustic in the United Kingdom. They also pointed out that the colours given by these resins are chiefly required for woollen fabrics, but that the use of the resins for dyeing wool is objectionable, as they have to be dissolved in alkalis, which, as pointed out above, is undesirable, as the alkali causes serious contraction of the wool fibre.

From these results it would appear that ordinary red and yellow *Xanthorrhœa* resins could not compete in the United Kingdom with fustic or with artificial yellow or brown dyes.

AUSTRALIAN SANDALWOOD OIL

In a note on the production of sandalwood oil in Mysore, published in this BULLETIN (1917, **15**, 108), reference was made to the "sandalwood" of Western Australia, which is derived from *Fusanus spicatus*, R.Br., a relative of the East Indian sandalwood tree, *Santalum album*, Linn. Western Australian sandalwood furnishes an oil which differs in several respects from the Indian oil, and only the latter oil is recognised by the British Pharmacopœia. A subsequent number of this BULLETIN (1919, **17**, 109) contained a note by Mr. C. E. Lane-Poole, Conservator of Forests in Western Australia, dealing with the botany of the Western Australian tree and the composition of the oil, in which it was stated that the oil contains from 75 to 80 per cent. of santalol, and that a process had been found by which the oil could be made to conform to the British Pharmacopœia standard. As little has been published regarding the composition of the oil, the product has been investigated at the Imperial Institute with a view to determining its constituents. Experiments have also been made regarding the possibility of preparing from the Australian oil a product which would respond to the constants required by the British Pharmacopœia. The preliminary results of this investigation are given in the following pages.

Constants of Oil

The oil investigated was an authentic sample of Australian sandalwood oil, obtained from a firm of importers in London. It was pale yellowish-brown in colour, somewhat viscous, and possessed an odour resembling that of *Santalum album* oil, though not so intense. It was examined with the following results, which are compared with those obtained in the case of a small sample of oil previously received from Western Australia, and with the British Pharmacopœia requirements for ordinary sandalwood oil derived from *S. album*.

	Western Australian sandalwood oil.		B.P. requirements for ordinary sandalwood oil (*Santalum aloum*).
	Present sample.	Previous sample.	
Specific gravity at $\frac{15^\circ \text{C.}}{15^\circ \text{C.}}$	0·958	0·972	0·973 to 0·985
Optical rotation αD	−0·25°	−0·87°	−13° to −21°
Refractive index n_D	1·503	1·510	1·498 to 1·508
Acid value	2·9	4·2	—
Ester value, before acetylation	4·7	8·1	—
,, ,, after ,,	170·8	173·8	—
Total alcohols ($C_{15}H_{24}O$) *per cent.*	76·3	78·5	not less than 90
Solubility in 70 per cent. alcohol	insoluble	insoluble	1 in 3 to 5 vols.

It will be seen that the two samples of Australian oil gave very similar results, and that none of the constants, except the refractive index, falls within the range of those given by the British Pharmacopœia for ordinary sandalwood oil (*S. album*).

Fractionation Experiments

The oil was distilled under 12 mm. pressure in an atmosphere of carbon dioxide, and a fraction, boiling at 130°–150° C., amounting to 15 per cent. of the oil, was collected. The residual oil was again distilled and a further fraction, boiling at 140°–155° C. under 7 mm. pressure, equivalent to an additional 15 per cent., expressed on the original oil, was removed. The effect of the distillation was, contrary to expectations, to lower the percentage of total alcohols, owing probably to the alcohol or alcohols having been partially decomposed on boiling, with the production of sesquiterpenes. The results of

examination of the fractions and residual oils, compared with the original oil, are given in the following table :

	Western Australian sandalwood oil.				
		First fractionation.		Second fractionation.	
	Original oil.	15 per cent. fraction.	Residue.	15 per cent. fraction.	Residue.
Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$ . .	0·958	0·922	0·963	0·922	0·973
Optical rotation αD . .	−0·25°	−4·5°	+0·2°	−4·0°	+1·2°
Refractive index n_D . .	1·503	1·496	1·509	1·498	1·513
Ester value after acetylation .	170·8	74·8[1]	142·3	94·2[1]	140·1[1]
Solubility in 70 per cent. alcohol	insoluble	insoluble	insoluble	insoluble	insoluble

[1] *These values represent:*
1st fraction (15 *per cent.*) : 4·6 *grams alcohols* ($C_{15}H_{24}O$).
2nd „ (15 „ „) : 6·0 „ „ „
Residue (70 „ „) : 43·0 „ „ „
i.e. *a total of* 53·6 *per cent. total alcohols as compared with* 76·3 *per cent. in the original oil.*

Not only is the percentage of total alcohols reduced by this method of distillation, but the residual oil is dextro-rotatory, and in this respect unlike *S. album* oil, which has a lævo-rotation of −13° to −21°.

For the purpose of comparison a sample of East Indian sandalwood oil was distilled under similar conditions, and it will be seen from the results given below that santalol does not suffer decomposition. This oil was distilled in an atmosphere of carbon dioxide and a 31 per cent. fraction, which boiled at 170° to 175° C. under 11 mm. pressure, was collected. The results of examination of the original oil, the fraction, and the residual oil are shown in the following table :

East Indian Sandalwood Oil

	Original oil.	31 per cent. fraction.	Residual oil.
Specific gravity at $\frac{15^\circ C.}{15^\circ C.}$	0·986	0·980	0·991
Optical rotation αD	−13·76°	−10·75°	−15·5°
Refractive index n_D	1·507	1·507	1·511
Ester value after acetylation . . .	204·7	199·4[1]	214·9[1]
Total alcohols . . . *per cent.*	95	92·1	1·00

[1] *These figures represent:*
31 *per cent. fraction:* 28·5 *grams santalol.*
69 „ „ *residual oil:* 69·0 *grams santalol.*
i.e. *a total of* 97·5 *per cent. santalol as compared with* 95 *per cent. in the original oil.*

Fractionation of Australian Sandalwood Oil with Steam

The oil was subjected to steam distillation, and a fraction amounting to 20 per cent. of the oil was separated. The character of the original oil, the fraction and the residual oil, were found to be as follows :

Australian Sandalwood Oil

	Original oil.	20 per cent. fraction.	Residual oil.
Specific gravity at $\frac{15° C.}{15° C.}$	0·958	0·926	0·966
Optical rotation αD	$-0·25°$	$-2·85°$	$+0·70°$
Refractive index n_D	1·503	1·497	1·508
Ester value after acetylation	170·8	87·2[1]	183·3[1]
Total alcohols ($C_{15}H_{24}O$) *per cent.*	76·3	36·7	83·5
Solubility in 70 per cent. alcohol	insoluble	insoluble	insoluble

[1] *These values represent :*
20 *per cent. fraction :* 7·4 *grams alcohols* $C_{15}H_{24}O$.
Residual oil : 66·8 *grams alcohols* $C_{15}H_{24}O$.
i.e. 74·2 *per cent. of total alcohols as compared with* 76·3 *per cent. in the original oil.*

The above results show that the alcohols present in the oil had not suffered appreciable decomposition by distillation with steam, as they did in the previous distillation experiments. The oil obtained by the removal of the 20 per cent. fraction had a higher specific gravity and contained a larger percentage of total alcohols than the original oil, but these constants were not raised sufficiently to bring them up to the British Pharmacopœia constants for *S. album* oil. It seems possible, however, that an oil could be obtained by steam distillation which would conform to all the British Pharmacopœia tests, except as regards optical rotation. Although in the present instance the removal of a 20 per cent. fraction was not sufficient to produce the desired result, on a larger scale more perfect fractionation with steam could be obtained, and it should not be necessary to remove more than 20 per cent. of the oil. A similar result could probably be obtained by rejecting a first fraction during the original distillation of the wood. Twenty per cent., however, is a large proportion of the oil, and unless a market could be found for this

fraction, the loss of this quantity might render the distillation of the oil unremunerative.

Nature of the Alcohols

Chapman (*Journ. Chem. Soc.*, 1901, 134) obtained by the oxidation of East Indian sandalwood oil an acid which he termed *santalenic acid.*

Following his methods the Australian sandalwood oil was oxidised by means of potassium permanganate and a crystalline acid was obtained which was shown to be identical with the santalenic acid produced from *S. album* oil. In the experiments made at the Imperial Institute a yield of 8 per cent. of this acid was obtained from the Australian oil, and 24 per cent. from a sample of *S. album* oil containing 95 per cent. of santalol; Chapman obtained an average yield of 20 per cent. of santalenic acid from East Indian sandalwood oil.

The formation of santalenic acid by the oxidation of Australian sandalwood oil provides a strong indication of the presence of some santalol in this oil. The small yield of this acid indicates that the proportion of santalol in the oil is much less than that in *S. album* oil, and suggests the presence of some other alcohol or alcohols.

General Conclusions

It is evident that the medicinal use of the Australian oil is limited by the fact that the British Pharmacopœia requires sandalwood oil to be the product of the East Indian sandalwood tree (*Santalum album*). Moreover, the Australian oil differs in odour, composition and optical rotation from the Indian oil. Before the Australian oil can be recognised officially as a medicinal substitute for East Indian oil it is necessary to prove that its therapeutic action is equal to that of *S. album* oil.

AFRICAN OIL PALM NUTS FROM CEYLON

Reference to the experimental cultivation of the African oil palm in Ceylon is made on p. 216 of this BULLETIN. In May 1919 a sample of oil palm nuts was received from Ceylon for examination, and two further samples were received this year. The nuts were obtained from oil palms growing at the Experimental Station, Anuradhapura. The palms were planted in November 1915, and yielded nuts for the first time in April 1918. The samples were as follows:

No. 1. "*Abe-pa*" *Palm Nuts.*—These were considerably smaller than nuts of the same variety from Nigeria, described in this BULLETIN (1909, **7**, 368).

No. 2. "*Oil Palm Nuts* (*Large*)."—This sample consisted mostly of palm nuts, but partly of entire palm fruits with a thin pericarp. Most of the nuts bore remains of the outer fibrous layer, and about 10 per cent. of them contained two kernels.

No. 3. "*Oil Palm Nuts* (*Small*)."—This sample consisted of thick-shelled palm nuts, a few of which contained two kernels.

The results of the examination of the samples at the Imperial Institute are given in the following table:

		No. 1.	No. 2.	No. 3.
Nuts				
Average length	*inches*	0·8	0·8	0·7
,, diameter	,,	0·6	0·7	0·5
,, weight	*grams*	2·4	3·5	1·6
,, thickness of shell	*inches*	0·11	0·11	0·08
Kernel	*per cent.*	22	22·5	25
Shell	,, ,,	78	77·5	75
Kernels				
Average length	*inches*	0·5	0·5	0·4
,, diameter	,,	0·4	0·4	0·3
,, weight	*grams*	0·5	0·8	0·4
Moisture	*per cent.*	6·6	5·5	5·4
Oil in kernels as received	,, ,,	51·7	52·6	55·5
,, expressed on the dry kernels	,, ,,	55·4	57·8	58·8

The entire fruits in sample No. 2 were composed of pericarp 23 per cent. and nut 77 per cent. The pericarps contained 4·5 per cent. of moisture and yielded 62·70 per

cent. of oil, equivalent to a yield of 65·6 per cent. on the dry material.

According to information supplied with the first sample of palm nuts from Anuradhapura, the palms were raised from seed of the "Abe-pa" variety.

The pericarps of the fruits in sample No. 2 yielded a lower percentage of oil than was obtained from the pericarps of two samples of "Abe-pa" palm fruits from West Africa, previously examined at the Imperial Institute, which contained 80·0 and 77·6 per cent. of oil respectively (calculated on the dry material). The fruits from Ceylon were, however, rather damaged, and in a dry condition, so that it is possible that a better yield of oil would be obtained from the fresh material.

The samples of kernels received this year (Nos. 2 and 3) yielded more palm kernel oil than the sample (No. 1) examined in 1919, and also more than a sample of "Abe-pa" kernels from West Africa which furnished 51·0 per cent. (calculated on the dry material).

The results furnished by these palm nuts from Ceylon are very satisfactory, and it is desirable that the cultivation of this variety of oil palm in Ceylon should be carefully considered. In this connection it was pointed out that it would be of much interest if further samples of the entire fruits of the palms growing at Anuradhapura could be forwarded to the Imperial Institute, in order to ascertain the yields of palm oil and palm kernel oil obtainable.

THE OTOBA NUTMEG

The kernels of a number of species of *Myristica* contain a fat suitable for soap and candle making (cf. this BULLETIN, 1914, **12**, 622), whilst the nutmeg (*M. fragrans*) yields a fat used in pharmacy. In 1918 samples of Otoba seeds (*Myristica Otoba*) and fat were received for examination at the Imperial Institute. It was stated that these products had been obtained from a forest tree found in the mountains of Colombia at an altitude of about 5,000 feet, and that the fat is used for veterinary purposes in that country.

Seeds

The seeds were almost spherical, with an average diameter of 0·8 inch, and consisted of shell 30 per cent. and kernel 70 per cent. The shell was brown, thin and brittle, and the kernel was covered by a closely adhering pale-brown skin. The kernels resembled nutmegs (*Myristica fragrans*) in their waxy consistency and characteristic mottled cross-section, but their odour was much less aromatic.

On distillation with steam the kernels yielded 7·2 per cent. of a practically colourless, mobile volatile oil, as compared with a yield of 6 to 15 per cent. of volatile oil from nutmegs. The oil was found to have the following constants, which are shown in comparison with those obtained at the Imperial Institute for a sample of commercial oil of nutmegs and the requirements of the British Pharmacopœia for the latter oil :

	Present sample of volatile oil from Otoba seeds.	Commercial oil of nutmegs.	Requirements of British Pharmacopœia for volatile oil of nutmegs.
Specific gravity at $\frac{15° C.}{15° C.}$.	0·894	0·900	0·870 to 0·925
Optical rotation a_D . .	+ 79·44°	+ 14·0°	+ 13° to + 30°
Refractive index n_D . .	1·502	1·477	1·474 to 1·484 (at 25° C.)
Acid value	13·6	1·3	—
Ester value before acetylation	nil	2·1	—
„ „ after „	20·0	29·3	—
Solubility in 90 per cent. alcohol	soluble in 16 vols. at 15° C.	soluble in 2·6 vols. at 15° C.	soluble in 3 vols.

The above results indicate that the volatile oil obtained from the Otoba seeds consists principally of terpenes, and that its constants do not agree with those of commercial nutmeg oil, or with the requirements of the British Pharmacopœia for volatile oil of nutmegs. Otoba oil therefore could not take the place of oil of nutmegs, and it is moreover deficient in certain odoriferous constituents which are present in small quantities in nutmeg oil and give the latter its characteristic pleasant odour.

The kernels extracted from the seeds at the Imperial Institute contained 14·3 per cent. of moisture, and, after crushing and the removal of the volatile oil by distillation,

they yielded 61·7 per cent. of fat, equivalent to a yield of 67·3 per cent. from the moisture-free kernels. The fat was pale yellow and of fairly hard consistency; it still retained a distinct odour of the volatile oil. On chemical examination it gave the following results, which are shown below in comparison with those recorded for the fat from Ceylon nutmegs freed from volatile oil:

	Present sample.	Figures recorded for Ceylon nutmeg fat.
Specific gravity	0·892 at $\frac{100° C.}{15° C.}$	0·944 at $\frac{50° C.}{50° C.}$
Melting point	37·8° C.[1]	49° C.
Acid value	16·8	14·0
Saponification value	198·9	199·6
Iodine value . . *per cent.*	20·1	35·7
Titer test	37·2° C.	—

[1] *Determined by the open-tube method.*

These results show that Otoba fat somewhat resembles that obtained from ordinary nutmegs; the Otoba kernels are, however, richer in fat than nutmegs which are recorded to yield only 38 to 40 per cent.

Fat

The fat received at the Imperial Institute was brownish-yellow, with an odour similar to that of the seeds. It was found to have the following composition:

	Per cent.
Moisture	22·4
Volatile oil	9·7
Fat	67·7
Dirt	0·2
Ash	0·1

After having been freed from moisture and dirt the fat was somewhat paler in colour. It had the following constants, which are shown below in comparison with the figures recorded for nutmeg butter:

	Otoba fat.	Nutmeg butter.
Specific gravity	0·899 at $\frac{100° C.}{15° C.}$	0·898 at $\frac{99° C.}{15° C.}$
Melting point	35·7° C.[1]	38° to 51° C.
Acid value	7·9	—
Saponification value	164·7	150 to 180
Iodine value . . *per cent.*	48·8	45 to 65

[1] *Determined by the open-tube method.*

The above figures show that the constants of this sample of Otoba fat are similar to those recorded for nutmeg butter, except as regards the melting point.

After the removal of the volatile oil by steam distillation, and filtering from dirt, the fat was pale brown, and had the following constants, which are shown in comparison with those obtained for the fat extracted at the Imperial Institute from the kernels freed from volatile oil (see p. 170):

		Present sample	Fat extracted from kernels at Imperial Institute.
Specific gravity at $\frac{100^\circ C.}{15^\circ C.}$		0·908	0·892
Melting point[1]		38·7° C.	37·8° C.
Acid value		9·7	16·8
Saponification value		197·0	198·9
Iodine value	*per cent.*	22·8	20·1
Titer test		37·2° C.	37·2° C.

[1] *Determined by the open-tube method.*

It will be seen from these figures that the constants of the two samples of the fat, freed from volatile oil, are in close agreement.

General Conclusions

The results of this investigation indicate that Otoba fat is similar to that obtained from ordinary nutmegs, but has much less aroma. It could probably be employed in pharmaceutical preparations for the same purposes as nutmeg butter, and, if available in large commercial quantities at a suitable price, it would be saleable for use in soap manufacture.

The volatile oil to which the odour of the fat is due differs from the volatile oil of nutmegs in composition and in being much less aromatic, and for these reasons it could not be employed as a substitute for the latter. It seems doubtful whether the volatile oil would have any commercial value in Europe.

The medicinal properties of the true nutmeg are due to the volatile oil which it contains, and if, as alleged, Otoba butter is of value for the treatment of skin diseases, this is probably largely due to the presence of the volatile oil, which would tend to act as a germicide, and to prevent the attacks of insects.

CURUA PALM OIL

A sample of Curua fruits from Brazil was forwarded to the Imperial Institute by the Department of Overseas Trade in February 1920.

The fruits averaged 2·5 in. in length, 1·5 in. in diameter and had an average weight of 35 grams. They bore at the apex a spike about ½ in. long, and at the base papery leaf-like bracts. The husk or pericarp, which was brown and fairly smooth on the outside and very fibrous within, enclosed a light-brown nut with a very hard shell about ¼ in. thick. In the latter respect the nuts are similar to Cohune nuts and, like them, would be difficult to crack (cf. this BULLETIN, 1914, **12**, 237). Each nut had one kernel with a brown skin and a hard, white, oleaginous interior with a cavity in the centre.

The kernels averaged 1 in. in length, 0·8 in. in breadth and 4·8 grams in weight.

The fruits were identified at Kew as those of *Attalea spectabilis*, Mart. They closely resembled Cohune fruits derived from *Attalea Cohune* except that the kernels were pointed at one end, whereas Cohune kernels are blunt at both ends.

About 50 per cent. of the fruits contained kernels which were either shrivelled or had been attacked by mould. The sound fruits were composed of pericarp 15·5 per cent., shell 71·3 per cent. and kernel 13·2 per cent., these figures being practically identical with those obtained for Cohune fruits.

The pericarp and kernels of the fruits yielded the amounts of fat shown below, in comparison with the corresponding figures for other palm fruits :

	Curua fruits.	Cohune fruits.	Oil palm fruits.	Coconut.
Pericarp :	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	11·1	8·4 to 10·2	—	—
Fat	2·9	9·3 to 20·6	55–70	—
Fat expressed on dry pericarp	3·3	10·3 to 22·5	—	—
Kernels :				
Moisture	4·3	4·5	6–8	5
Fat	62·5	65 to 72	48–51	63–70
Fat expressed on dry kernels	65·3	68 to 75	52–54	66–74

The fat from the pericarp was of greenish colour, and semi-solid. The yield from the dry pericarp (3·3 per cent.)

is much lower than that obtained from the pericarp of Cohune fruits, and is too small to be worth extraction.

The fat from the kernels was a soft, pale cream-coloured solid product, with a pleasant odour resembling that of oil palm kernels. It was examined with the following results in comparison with the corresponding figures for the fats from Cohune kernels, palm kernels and coconuts :

	Curua kernel fat.	Cohune kernel fat.	Palm kernel fat.	Coconut fat.
Specific gravity at $\frac{100° C.}{15° C.}$	0·8693	0·868–0·871	0·873	0·874
Refractive index at 40° C.	1·447	—	1·449–1·450	1·448–1·449
Acid value . . .	1·2	1·2–20·4	—	—
Saponification value .	259·5	252·4–256·5	245–248	260–262
Iodine value . *per cent.*	8·9	11·0–13·7	14·0–17·5	7–9
Unsaponifiable matter *per cent.*	0·36	0·2–0·3	0·22	0·15–0·3
Volatile acids, soluble[1] .	6·26	6·8–8·3	5·0–7·6	6·65–8·0
„ „ insoluble[1] .	15·61	12·5–15·4	10–12	15–20
Melting point . . .	23·6° C.	22–24° C.	26–29° C.	23–26° C.
Solidifying point of fatty acids	24·6° C.	19·7–21·0° C.	20·0–25·5° C.	21·2–25·2° C.

[1] *Number of c.c. of decinormal alkali required to neutralise acid from 5 grams of oil.*

The meal left after the extraction of the fat from the kernels was brownish-pink, and had a faint odour and taste resembling those of coconut. It was analysed with the following results, which are shown in comparison with corresponding figures for Cohune meal, palm kernel cake and coconut cake :

	Curua meal. As analysed.	Curua meal. Calculated to contain 7 per cent. of fat.	Cohune meal.	Palm kernel cake.	Coconut cake.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	8·9	8·3	9·5	9·4	11·9
Crude proteins . . .	16·8	15·6	22·4	17·8	21·8
Fat	0·1	7·0	7·0	8·2	8·4
Carbohydrates (by difference)	52·8	49·1	40·0	50·6	42·6
Fibre	15·1	14·1	16·1	10·1	9·4
Ash	6·3	5·9	5·0	3·9	5·9
Nutrient ratio . . .	1 : 3·2	1 : 4·2	1 : 2·5	1 : 3·9	1 : 2·8
Food units . . .	95	106	113	116	118

These figures show that Curua meal is fairly rich in proteins, but not quite equal to the other materials in this respect. The amount of crude fibre is not quite so high as in Cohune meal.

General Conclusions

The fat from Curua kernels is of similar consistence to Cohune kernel fat, and has almost identical constants. The kernels in the present sample of fruits yielded, however, a somewhat lower percentage of fat than any of the samples of Cohune kernels examined at the Imperial Institute.

Curua kernel fat when refined would be suitable for edible purposes. It is similar in colour and odour to palm kernel fat, but has a lower melting point.

Curua kernels yield a considerably higher percentage of fat than palm kernels, and if available in commercial quantities should realise a higher price than the latter, which were recently quoted at £31 per ton in the United Kingdom (July 1920).

The residual meal, judging from the results of its analysis, should be nearly equal in value as a feeding stuff to palm kernel meal, which was recently quoted at £11 5*s.* to £11 15*s.* ex mill, in Liverpool (July 1920). Practical trials would, however, be necessary before Curua kernel meal or cake could be safely recommended for general use as a feeding stuff.

CEYLON SANDS FOR GLASS MANUFACTURE

DURING 1916 the Assistant Mineral Surveyor of the Ceylon Mineral Survey, which is being conducted in connection with the Imperial Institute, investigated the deposits of sand which occur in the Jaffna peninsula in the extreme north of Ceylon and in the Negombo-Chilaw district on the west coast of the island. Samples of sand from various localities in these regions were received at the Imperial Institute in 1918 in order to ascertain their value for glass making.

The bedrock of the Jaffna peninsula is a marine limestone above which are deposits consisting of raised beaches, sand dunes, modern beaches and soil. Sand dunes are well developed near the shores of the peninsula, particularly so on the east side, where they extend from Point Pedro, in the extreme north of Mullaitivu, a distance of over 50

miles. The older dunes, which are of a buff or reddish colour owing to the presence of iron, are best seen in the south of the peninsula. The sand of the modern dunes is remarkably pure and in several places is suitable for glass-making, but the deposits are not conveniently situated for exploitation. Five samples of sand (Nos. 1–5) from the south of the peninsula and five (Nos. 6–9 and 18) from the eastern side have been examined at the Imperial Institute.

The coastal area of the Negombo-Chilaw district is on the whole low-lying, and, with the exception of occasional protuberances of granitic rock, is composed of derivatives of the ancient crystalline series. Laterised ridges and linear groups of knolls form, for the most part, the higher ground. Between the ridges lie the alluvial deposits of the paddy fields, and slightly above them in level a white sand occurs. The latter is the ground on which the Dutch planted their cinnamon gardens, and on which in more recent years coconut plantations have been made. Large areas of Crown jungle exist from which the sand could be worked, but so far only rough estimates have been made of the quantity of sand available in the different deposits. In the most promising area—Horakele, near Madampe—the superficial extent is put at 500 acres. The depth to which the sand could be dug is limited by the low-lying nature of the deposit, as water is encountered close to the surface. The quantity of sand per foot depth per acre is estimated at 3,200 tons, so that a very large quantity is available. At Horagolla, near Nattahdiya, the tonnage is about the same, whilst the area of Crown jungle here is said to be about 1,000 acres. These deposits are more conveniently situated for working than those in Jaffna peninsula. Five samples of sand from Horakele and two from Horagolla were received for examination, and one from Kadawewa, where the deposit is much less extensive than in the other two localities.

No. 1. "*M.S.C.* 192. *A.*1. *Sand from Chavakachcheri, dunes S.W. of station.*"—This was a white sand composed chiefly of somewhat rounded quartz grains. The heavy minerals amounted to 1·3 per cent. of the material and consisted chiefly of ilmenite and sillimanite, with small amounts of garnet, zircon, rutile, tourmaline, staurolite,

spinel, andalusite, hornblende, corundum, magnetite, monazite and pyrite.

The sand was chemically analysed with the following results:

		Per cent
Silica	SiO_2	97·78
Alumina	Al_2O_3	0·75
Ferric oxide	Fe_2O_3	0·33
Titanic oxide	TiO_2	0·55
Zirconia	ZrO_2	0·02
Lime	CaO	0·06
Magnesia	MgO	0·04
Potash	K_2O	0·02
Soda	Na_2O	0·24
Loss on ignition		0·14

The results of mechanical analysis were as follows:

	Per cent
Remaining on a 30-mesh screen [1]	nil
Passing a 30-mesh screen and remaining on a 60-mesh screen	4·4
" 60 " " " 90 " "	47·5
" 90 " " " 120 " "	47·0
" 120 " "	1·1

[1] i.e. *a screen with* 30 *meshes per linear inch.*

The percentage of iron oxide and heavy minerals is too high to permit of the use of this sand for the production of best or medium-quality glass. The sand could, however, be used for making cheap glass, as its mechanical composition is satisfactory.

No. 2. "*M.S.C.* 192. *A.*2. *Sand from Chavakachcheri, below surface of dunes.*"—This material resembled the preceding sample, but the quartz grains were rather coarser. The heavy minerals amounted to 1·3 per cent. of the material, and were chiefly ilmenite and sillimanite, with small amounts of zircon, rutile, garnet, spinel, tourmaline, magnetite, corundum and anatase.

The sand was chemically analysed with the following results:

		Per cent.
Silica	SiO_2	96·60
Alumina	Al_2O_3	0·78
Ferric oxide	Fe_2O_3	0·49
Titanic oxide	TiO_2	0·50
Zirconia	ZrO_2	0·04
Lime	CaO	0·24
Magnesia	MgO	0·31
Potash	K_2O	0·38
Soda	Na_2O	0·32
Loss on ignition		0·19

The results of the mechanical analysis were as follows :

	Per cent.
Remaining on a 30-mesh screen	1·6
Passing a 30-mesh screen and remaining on a 60-mesh screen	46·5
" 60 " " " 90 " "	31·1
" 90 " " " 120 " "	7·4
" 120 " "	13·4

This sand contains too large a percentage of iron oxide and heavy minerals to permit of its use for the manufacture of high-grade or medium-grade glass. It could be used for the production of cheap glass bottles, but even for this purpose it contains rather too large a percentage of sand passing a 120-mesh screen.

No. 3. "*M.S.C.* 192. *No. A.*4. *Sand from Chavakachcheri, dunes N. of station.*"—In this sample the heavy minerals amounted to 1·1 per cent., and consisted mainly of ilmenite and sillimanite, with small amounts of garnet, rutile, zircon, spinel, kyanite, tourmaline and magnetite.

The sand was chemically analysed with the following results :

		Per cent.
Silica	SiO_2	97·16
Alumina	Al_2O_3	0·88
Ferric oxide	Fe_2O_3	0·20
Titanic oxide	TiO_2	0·65
Zirconia	ZrO_2	0·04
Lime	CaO	0·11
Magnesia	MgO	0·05
Potash	K_2O	0·03
Soda	Na_2O	0·22
Loss on ignition		0·34

The results of the mechanical analysis were as follows :

	Per cent.
Remaining on a 30-mesh screen	7·3
Passing a 30-mesh screen and remaining on a 60-mesh screen	11·3
" 60 " " " 90 " "	43·0
" 90 " " " 120 " "	20·3
" 120 " "	18·

This sand contains too large a percentage of iron oxide and heavy minerals to permit of its use for the manufacture of high-grade or medium-grade glass. It could be used for the production of cheap glass bottles, but even for this purpose it contains rather too large a percentage of sand passing a 120-mesh screen.

No. 4. "*M.S.C.* 192 *A.*5. *Sand from dunes at Kolumputturai.*"—In this sand the heavy minerals amounted

to 1·55 per cent., and consisted chiefly of ilmenite, with some sillimanite and small amounts of garnet, epidote, rutile, zircon, spinel, magnetite, tourmaline, kyanite and andalusite.

The sand was chemically analysed with the following results :

		Per cent.
Silica	SiO_2	97·78
Alumina	Al_2O_3	0·63
Ferric oxide	Fe_2O_3	0·15
Titanic oxide	TiO_2	0·21
Zirconia	ZrO_2	0·06
Lime	CaO	0·25
Magnesia	MgO	0·07
Potash	K_2O	0·11
Soda	Na_2O	0·34
Loss on ignition		0·19

The results of mechanical analysis were as follows :

	Per cent.
Remaining on a 30-mesh screen	0·3
Passing a 30-mesh screen and remaining on a 60-mesh screen	32·5
,, 60 ,, ,, ,, 90 ,, ,,	59·2
,, 90 ,, ,, ,, 120 ,, ,,	6·1
,, 120 ,, ,,	1·9

This sand is unsuitable for the production of best or medium-quality glass owing to the amounts of heavy minerals and iron oxide present. It could, however, be used for making cheap glass-ware. Its mechanical composition is satisfactory.

No. 5. "M.S.C. 192. A.*7. Sand dunes, Kovilpitiya."*—The quartz grains composing this sand contain numerous inclusions. The free heavy minerals amounted to 2·53 per cent. of the material and consisted chiefly of ilmenite and sillimanite, with small amounts of garnet, rutile, epidote, zircon, spinel, magnetite, tourmaline and andalusite.

The sand was chemically analysed with the following results :

		Per cent.
Silica	SiO_2	98·06
Ferric oxide	Fe_2O_3	0·38
Alumina	Al_2O_3	0·69
Titanic oxide	TiO_2	0·55
Zirconia	ZrO_2	0·03
Lime	CaO	0·05
Magnesia	MgO	0·06
Potash	K_2O	0·02
Soda	Na_2O	0·11
Loss on ignition		0·18

The results of mechanical analysis were as follows:

	Per cent
Remaining on a 30-mesh screen	nil
Passing a 30-mesh screen and remaining on a 60-mesh screen	24·0
" 60 " " " 90 " "	65·9
" 90 " " " 120 " "	9·9
" 120 " "	0·2

This sand contains too large a percentage of heavy minerals to permit of its being used in glass manufacture.

No. 6. "*M.S.C.* 192. *A.*14. *Ampan, first line of dunes E. of cultivation.*"—This sand contained a few grains of felspar (orthoclase). The heavy minerals amounted to 0·14 per cent. of the material, and consisted chiefly of sillimanite with some rutile and ilmenite and small amounts of zircon, garnet, spinel, hornblende, hypersthene, magnetite, tourmaline, staurolite, epidote and kyanite.

The sand was chemically analysed with the following results:

		Per cent.
Silica	SiO_2	99·03
Alumina	Al_2O_3	0·41
Ferric oxide	Fe_2O_3	0·25
Titanic oxide	TiO_2	0·07
Zirconia	ZrO_2	0·01
Lime	CaO	0·10
Magnesia	MgO	0·03
Potash	K_2O	0·30
Soda	Na_2O	0·40
Loss on ignition		0·17

The results of mechanical analysis were as follows:

	Per cent.
Remaining on a 30-mesh screen	2·2
Passing a 30-mesh screen and remaining on a 60-mesh screen	71·8
" 60 " " " 90 " "	23·4
" 90 " " " 120 " "	1·7
" 120 " " "	0·9

Although the quantity of heavy minerals in this sand was fairly low, it contained too large a percentage of iron oxide to permit of its use in the manufacture of best or medium-quality glass. The mechanical condition of the sand is, however, satisfactory, and it could be used for making cheap glass ware.

No. 7. "*M.S.C.* 192. *A.*17. *Ampan* 200 *yards from beach.*"—The quartz was in coarse grains, with abundant inclusions. The free heavy minerals amounted to 0·06 per cent. of the material and included ilmenite, sillimanite,

rutile, zircon, garnet, spinel, hornblende, hypersthene and staurolite.

The sand was chemically analysed with the following results :

		Per cent.
Silica	SiO_2	98·72
Alumina	Al_2O_3	0·22
Ferric oxide	Fe_2O_3	0·15
Titanic oxide	TiO_2	0·04
Zirconia	ZrO_2	0·01
Lime	CaO	0·06
Magnesia	MgO	0·05
Potash	K_2O	0·06
Soda	Na_2O	0·28
Loss on ignition		0·02

The results of mechanical analysis were as follows :

	Per cent.
Remaining on a 30-mesh screen	55·8
Passing a 30-mesh screen and remaining on a 60-mesh screen	40·7
,, 60 ,, ,, ,, 90 ,, ,,	3·0
,, 90 ,, ,, ,, 120 ,, ,,	0·3
,, 120 ,, ,,	0·2

The chemical composition of this sand renders it unsuitable for the production of best-quality glass owing to the amount of iron oxide present. This, however, would not prevent the sand from being used for making medium-quality glass, but the mechanical condition of the sand is not satisfactory. The material not passing a 30-mesh screen would need to be reduced either by grinding or screening.

No. 8. "*M.S.C.* 192. *A.*18. *Ampan,* 3 *ft. below surface on sand flats.*"—This sand contained a small proportion of felspar. The heavy minerals amounted to 0·07 per cent. of the material and included sillimanite, ilmenite, rutile, zircon, hornblende, garnet, tourmaline, kyanite and blue spinel.

The sand was chemically analysed with the following results :

		Per cent.
Silica	SiO_2	98·60
Alumina	Al_2O_3	0·66
Ferric oxide	Fe_2O_3	0·19
Titanic oxide	TiO_2	0·05
Zirconia	ZrO_2	0·005
Lime	CaO	0·20
Magnesia	MgO	0·05
Potash	K_2O	0·20
Soda	Na_2O	0·16
Loss on ignition		0·25

The results of the mechanical analysis were as follows :

	Per cent.
Remaining on a 30-mesh screen	13·6
Passing a 30-mesh screen and remaining on a 60-mesh screen	56·9
" 60 " " " 90 " "	28·0
" 90 " " " 120 " "	1·3
" 120 " "	0·2

The sand would only be suitable for the production of cheap glassware, as it contains a good deal of iron oxide and a large percentage of grains not passing a 30-mesh screen.

No. 9. "*M.S.C.* 192. *A.*19. *Between Ampan and Nokakovil.*"—The quartz was coarse, with numerous inclusions. A few grains of orthoclase were observed. The free heavy minerals, which consisted of ilmenite, sillimanite, rutile, zircon, hornblende, garnet and blue spinel, amounted to 0·03 per cent. of the material, but more than this must have been present as inclusions in the quartz.

The sand was analysed with the following results :

		Per cent.
Silica	SiO_2	97·87
Alumina	Al_2O_3	0·90
Ferric oxide	Fe_2O_3	0·30
Titanic oxide	TiO_2	0·34
Zirconia	ZrO_2	0·04
Lime	CaO	0·07
Magnesia	MgO	0·12
Potash	K_2O	0·26
Soda	Na_2O	0·02
Loss on ignition		0·18

The results of the mechanical analysis were as follows :

	Per cent.
Remaining on a 30-mesh screen	64·4
Passing a 30-mesh screen and remaining on a 60-mesh screen	33·2
" 60 " " " 90 " "	2·1
" 90 " " " 120 " "	0·2
" 120 " "	0·1

This sand is too coarse for use in glass-making, but if ground so as to reduce the percentage of grains not passing a 30-mesh screen it could be used for the production of cheap glass bottles. It contains too large a percentage of iron oxide to permit of its being used for high- or medium-quality glass.

No. 10. "*M.S.C.* 192. *B.*13. *Crude sample, washed, from Madampe Mills, Horakele.*"—This was a very coarse sand, with little fine material. The heavy minerals

amounted to 0·36 per cent. of the material, and consisted chiefly of ilmenite and sillimanite, with smaller amounts of rutile, zircon, spinel, garnet, hypersthene, magnetite, monazite, and probably a little cassiterite.

The sand was chemically analysed with the following results:

		Per cent.
Silica	SiO_2	99·20
Alumina	Al_2O_3	0·20
Ferric oxide	Fe_2O_3	0·12
Titanic oxide	TiO_2	0·07
Zirconia	ZrO_2	trace
Lime	CaO	0·10
Magnesia	MgO	0·05
Potash	K_2O	0·02
Soda	Na_2O	0·31
Loss on ignition		0·08

The results of the mechanical analysis were as follows:

	Per cent.
Remaining on a 30-mesh screen	42·0
Passing a 30-mesh screen and remaining on a 60-mesh screen	54·5
„ 60 „ „ „ 90 „ „	3·0
„ 90 „ „ „ 120 „ „	0·3
„ 120 „ „	0·2

This sand would be suitable for the production of medium-quality glassware if its mechanical conditions were improved by grinding in order to reduce the quantity of material not passing a 30-mesh screen.

No. 11. "*M.S.C.* 192. *B.*14. *Crude sample, Madampe Hills, Horakele.*"—A coarse sand, with occasional grains of felspar. The heavy minerals amounted to 2·0 per cent. of the material and consisted chiefly of ilmenite and sillimanite, together with rutile, zircon, spinel, garnet, magnetite, monazite, hypersthene, tourmaline, andalusite and probably a little cassiterite.

The sand was chemically analysed with the following results:

		Per cent.
Silica	SiO_2	97·80
Alumina	Al_2O_3	0·60
Ferric oxide	Fe_2O_3	0·40
Titanic oxide	TiO_2	0·70
Zirconia	ZrO_2	0·04
Lime	CaO	0·06
Magnesia	MgO	0·15
Potash	K_2O	0·06
Soda	Na_2O	0·18
Loss on ignition		0·02

The results of the mechanical analysis were as follows:

	Per cent.
Remaining on a 30-mesh screen	33·5
Passing a 30-mesh screen and remaining on a 60-mesh screen	55·8
,, 60 ,, ,, ,, 90 ,, ,,	8·6
,, 90 ,, ,, ,, 120 ,, ,,	1·3
,, 120 ,, ,,	0·8

This specimen contains too large a percentage of iron oxide and heavy minerals to permit of its use for any but the commonest glass, and even for this purpose it would need grinding in order to reduce the percentage of grains not passing a 30-mesh screen.

No. 12. "*M.S.C.* 192. *B.*15. *Crude sample, washed, Madampe Hills, Horakele.*"—This was a coarse sand, containing 1·34 per cent. of heavy minerals, which consisted chiefly of ilmenite and sillimanite, together with rutile, zircon, garnet, spinel, monazite, magnetite, hornblende and tourmaline.

The sand was chemically analysed with the following results:

		Per cent.
Silica	SiO_2	97·30
Alumina	Al_2O_3	0·90
Ferric oxide	Fe_2O_3	0·36
Titanic oxide	TiO_2	0·61
Zirconia	ZrO_2	0·04
Lime	CaO	0·04
Magnesia	MgO	0·12
Potash	K_2O	0·02
Soda	Na_2O	0·28
Loss on ignition		0·19

The results of the mechanical analysis were as follows:

	Per cent
Remaining on a 30-mesh screen	38·0
Passing a 30-mesh screen and remaining on a 60-mesh screen	47·5
,, 60 ,, ,, ,, 90 ,, ,,	11·5
,, 90 ,, ,, ,, 120 ,, ,,	2·0
,, 120 ,, ,,	1·0

This specimen contains too large a percentage of iron oxide and heavy minerals to permit of its use for any but the commonest glassware, and even for this purpose it would need grinding in order to reduce the percentage of grains not passing a 30-mesh screen.

No. 13. "*M.S.C.* 192. *B.*16. *Crude sample, washed and fines sifted off, from Madampe Hills, Horakele.*"—The

quartz was coarse, and contained the usual inclusions. The heavy minerals amounted to 0·22 per cent. of the material and consisted chiefly of coarse grains of sillimanite, garnet and spinel, with very little ilmenite, rutile, etc.

The sand was chemically analysed with the following results:

		Per cent.
Silica	SiO_2	99·15
Alumina	Al_2O_3	0·18
Ferric oxide	Fe_2O_3	0·02
Titanic oxide	TiO_2	0·01
Zirconia	ZrO_2	0·01
Lime	CaO	0·15
Magnesia	MgO	0·13
Potash	K_2O	0·18
Soda	Na_2O	0·17
Loss on ignition		0·03

The results of the mechanical analysis were as follows:

	Per cent.
Remaining on a 30-mesh screen	63·3
Passing a 30-mesh screen and remaining on a 60-mesh screen	35·6
,, 60 ,, ,, ,, 90 ,, ,,	1·0
,, 90 ,, ,, ,, 120 ,, ,,	0·04
,, 120 ,, ,,	0·02

This sand is suitable in chemical composition for the manufacture of the best-quality glass, but its mechanical condition is not satisfactory, and it would need grinding so as to reduce the percentage of grains not passing a 30-mesh screen.

No. 14. "*M.S.C.* 192. *B.*17. *Crude sample, washed and fines sifted off, from Madampe Hills, Horakele.*"—A coarse sand with 1·48 per cent. of heavy minerals, which consisted chiefly of coarse grains of sillimanite, spinel and garnet, with small amounts of rutile, tourmaline, ilmenite, andalusite and kyanite.

The sand was chemically analysed with the following results:

		Per cent.
Silica	SiO_2	97·86
Alumina	Al_2O_3	0·67
Ferric oxide	Fe_2O_3	0·08
Titanic oxide	TiO_2	0·06
Zirconia	ZrO_2	0·03
Lime	CaO	0·15
Magnesia	MgO	0·13
Potash	K_2O	0·12
Soda	Na_2O	0·46
Loss on ignition		0·08

The results of the mechanical analysis were as follows :

	Per cent.
Remaining on a 30-mesh screen	26·1
Passing a 30-mesh screen and remaining on a 60-mesh screen	70·4
„ 60 „ „ „ 90 „ „	3·5
„ 90 „ „ „ 120 „ „	0·02
„ 120 „ „	nil

This specimen contains too large a percentage of heavy minerals to permit of its use for any but the commonest glass, and even for this purpose it would need grinding in order to reduce the percentage of grains not passing a 30-mesh screen.

No. 15. "*M.S.C.* 192. *B.*19. *Crude sand, washed and fines sifted off, from Horagolla.*"—A coarse sand, similar in grade to the preceding sample. The heavy minerals amounted to 0·71 per cent. of the material and consisted chiefly of sillimanite and spinel, with small amounts of rutile, garnet, ilmenite and hypersthene.

The sand was chemically analysed with the following results :

		Per cent.
Silica	SiO_2	99·26
Alumina	Al_2O_3	0·22
Ferric oxide	Fe_2O_3	0·16
Titanic oxide	TiO_2	0·05
Zirconia	ZrO_2	0·01
Lime	CaO	0·07
Magnesia	MgO	0·10
Potash	K_2O	0·10
Soda	Na_2O	0·14
Loss on ignition		0·05

The results of the mechanical analysis were as follows :

	Per cent.
Remaining on a 30-mesh screen	24·9
Passing a 30-mesh screen and remaining on a 60-mesh screen	71·7
„ 60 „ „ „ 90 „ „	3·4
„ 90 „ „	nil

This sand might be used for the production of medium-quality glass if its mechanical condition were improved by grinding in order to reduce the percentage of grains not passing a 30-mesh screen.

No. 16. "*M.S.C.* 192. *B.*20. *Crude sand, from Horagolla.*"—This sand was not so coarse as the preceding sample, and contained 2·45 per cent. of heavy minerals, chiefly ilmenite, sillimanite and spinel, with small amounts of rutile, zircon, garnet, tourmaline and andalusite.

The sand was chemically analysed with the following results :

		Per cent.
Silica	SiO_2	97·47
Alumina	Al_2O_3	1·24
Ferric oxide	Fe_2O_3	0·12
Titanic oxide	TiO_2	0·35
Zirconia	ZrO_2	0·04
Lime	CaO	0·09
Magnesia	MgO	0·31
Potash	K_2O	0·14
Soda	Na_2O	0·08
Loss on ignition		0·12

The results of the mechanical analysis were as follows :

	Per cent
Remaining on a 30-mesh screen	17·4
Passing a 30-mesh screen and remaining on a 60-mesh screen	70·8
,, 60 ,, ,, ,, 90 ,, ,,	11·6
,, 90 ,, ,, ,, 120 ,, ,,	0·2
,, 120 ,, ,,	0·04

This specimen contained too large a percentage of heavy minerals to permit of its use for any but the commonest glass, and even for this purpose it would need grinding in order to reduce the percentage of grains not passing a 30-mesh screen.

No. 17. "*M.S.C.* 192. *B.*28. *Sand from Kadawewa, crude sample, washed and fines sifted off.*"—A coarse sand containing 0·17 per cent. of heavy minerals, which consisted chiefly of coarse sillimanite and spinel with small amounts of rutile, ilmenite, garnet and andalusite.

The sand was chemically analysed with the following results :

		Per cent.
Silica	SiO_2	98·70
Alumina	Al_2O_3	0·11
Ferric oxide	Fe_2O_3	0·13
Titanic oxide	TiO_2	0·09
Zirconia	ZrO_2	0·008
Lime	CaO	0·10
Magnesia	MgO	0·06
Potash	K_2O	0·04
Soda	Na_2O	0·22
Loss on ignition		0·06

The results of the mechanical analysis were as follows :

	Per cent.
Remaining on a 30-mesh screen	40·1
Passing a 30-mesh screen and remaining on a 60-mesh screen	57·1
,, 60 ,, ,, ,, 90 ,, ,,	2·8
,, 90 ,, ,,	nil

This sand might be used for the production of medium-quality glass if its mechanical condition were improved by grinding in order to reduce the percentage of grains not passing a 30-mesh screen.

No. 18. "*M.S.C.* 198. *Crude sand. Point Pedro.*"—The quartz was somewhat finer grained than in most of the samples of the M.S.C. 192 series, and contained less numerous inclusions.

Occasional grains of calcite, felspar and graphite were observed.

The heavy minerals amounted to 0·13 per cent. of the material and consisted chiefly of sillimanite and ilmenite, with some rutile, zircon, hornblende, garnet and epidote, and small amounts of spinel, tourmaline, andalusite and kyanite.

The sand was chemically analysed with the following results :

		Per cent.
Silica	SiO_2	97·48
Alumina	Al_2O_3	0·17
Ferric oxide	Fe_2O_3	0·15
Titanic oxide	TiO_2	0·05
Zirconia	ZrO_2	0·006
Lime	CaO	0·27
Magnesia	MgO	0·17
Potash	K_2O	0·60
Soda	Na_2O	0·26
Loss on ignition		0·57

The results of the mechanical analysis were as follows :

	Per cent.
Remaining on a 30-mesh screen	15·3
Passing a 30-mesh screen and remaining on a 60-mesh screen	46·7
,, 60 ,, ,, ,, 90 ,, ,,	33·4
,, 90 ,, ,, ,, 120 ,, ,,	4·0
,, 120 ,, ,,	0·6

This sand is of satisfactory chemical composition for the production of medium-quality glass, but it contains a large percentage of grains not passing a 30-mesh screen, which should be reduced by grinding or screening.

Summary of Results

These sands were all of fairly good colour, but most of them were too coarse in grain and included too large a percentage of heavy minerals (chiefly ilmenite) for good glass

sands. Some of the samples had been sifted, and the fines rejected before they were sent to the Imperial Institute; this treatment had eliminated most of the free grains of ilmenite, but not the sillimanite, which is coarser, or the minute rutiles, zircons, etc., which occur abundantly as inclusions in the quartz grains.

The quartz grains were mostly coarse, sub-angular, and with many inclusions. Felspar was noticed in a few cases, and may be present in others in very small amounts. Calcite was occasionally observed. Of the heavy minerals, ilmenite and sillimanite were the most abundant, whilst rutile, spinel, garnet and zircon were usually present in small amounts, sometimes accompanied by hornblende, hypersthene, kyanite, andalusite, magnetite, epidote, corundum, pyrites, tourmaline, staurolite and anatase. A few grains of monazite were present in Nos. 1, 10, 11 and 12 (M.S.C. 192, A.1, B.13, B.14 and B.15), and a small amount of cassiterite was probably present in Nos. 10 and 11 (M.S.C. 192, B.13 and B.14).

Remarks

The requirements of a good glass sand may be divided into two categories: (*a*) mechanical, (*b*) chemical.

The mechanical composition of a glass sand is of great importance. The grains should preferably be either angular or sub-angular, of fairly uniform size and falling between the limits $\frac{1}{50}$ in. to $\frac{1}{250}$ in. in diameter. The presence of much sand finer than the lower limit is objectionable as it tends to produce an uneven composition in the melt. It is true that sands rather coarser than the above have been ground in the United Kingdom, and used for the manufacture of chemical glassware during the war, but the expense of grinding is considerable in proportion to the value of the sand. Heavy minerals should not exceed 1 per cent., whilst zircon, ilmenite, anatase, brookite and rutile are very objectionable as they resist solution in the melt and give rise to specks in the glass.

The chemical requirements depend upon the quality of the glass which it is intended to produce. The production of the best-quality glass, such as optical glass, best sheet and flint, crystal tableware, etc., requires a sand containing

not more than 0·08 per cent. of ferric oxide and preferably less than 0·02 per cent. The quantities of alumina, magnesia and lime should also be low.

Sands stained with oxide of iron have been utilised by certain firms in the United Kingdom by giving them a preliminary treatment with nitre-cake and so reducing the percentage of iron. This treatment, however, is only commercially possible where supplies of nitre-cake are available at a cheap rate.

Medium-quality glass, such as chemical glassware, the best bottles, globes, chimneys, pressed ware, etc., can be produced from sand containing up to about 0·1 per cent. of ferric oxide.

For the commonest glass (ordinary bottles, etc.) sand carrying up to 1·0 per cent. of ferric oxide can be used.

None of the present samples from Ceylon is suitable for the production of the best-quality glass when both chemical composition and mechanical condition are considered, but No. 13 (M.S.C. 192, B.16) would be suitable if its mechanical conditions were improved by grinding. Grinding would also render the sands represented by samples Nos. 7, 10, 15, 17, and 18 (M.S.C. 192, A.17, B.13, B.19, B.28 and M.S.C. 198) suitable for the production of medium-quality glass.

For the production of common glass, samples Nos. 4 and 6 (M.S.C. 192, A.5, and A.14) are suitable from both the chemical and mechanical standpoint, and possibly Nos. 1, 2 and 3 (M.S.C. 192, A.1, A.2, and A.4) could be used without further treatment. Samples 8, 9, 11, 12, 14, and 16 (M.S.C. 192, A.18, A.19, B.14, B.15, B.17 and B. 20) are too coarse, and would require grinding before use, but this procedure would be somewhat expensive and unlikely to be practicable commercially. Sample No. 5 (M.S.C. 192, A.7) is unsuitable for glass manufacture owing to the large percentage of heavy minerals present.

GUANO FROM LATHAM ISLAND, NEAR ZANZIBAR

Latham Island is situated in the Indian Ocean, forty-one miles south-east of Zanzibar and twenty-eight miles

east from the mainland of Africa. It is 350 yards long and 180 yards wide, and the surface is 10 ft. above spring-tide level, but landing is bad and dangerous. According to the Director of Agriculture, Zanzibar, the central plateau of the island is covered with guano to an average depth of one foot. A sample of this guano was sent to the Imperial Institute for examination last year. It consisted of an earthy phosphatic material, containing lumps of phosphate and carbonate of lime. Plant remains, sand, etc., were also present.

The guano was chemically examined with the following results, which are shown in comparison with figures recorded for well-known typical commercial guanos from Peru and South Africa:

—		Present sample.	Peruvian guano.		S. African guano.	
			Guanape.	Chinchas.	Saldanha Bay.	Ichaboe Island.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Total nitrogen	N	0·76[1]	11·0	16·09	1·41	—
Total phosphoric anhydride	P_2O_5	29·52[2]	12·25	—	24·52	11·19
"Available" do.	P_2O_5	19·10	—	9·29	—	—
Lime	CaO	35·36[2]	—	—	24·26	—
Total potash	K_2O	0·33	2·5	2·5	—	—
Organic matter		1·88	—	—	—	—
Moisture, on heating at 105° C.	H_2O	15·24	25·88	—	17·04	17·97

[1] *Including nitrogen present as:*
Nitrates, expressed as nitrogen pentoxide N_2O_5 1·19 *per cent. of the original material.*
Ammonia . . . . NH_3 0·015 *per cent. of the original material.*

[2] *Equivalent to:*
Calcium phosphate $Ca_3P_2O_8$ 62·78 *per cent. of the original material.*
Calcium carbonate $CaCO_3$ 3·75 " " " "

It will be seen from the above results that the present sample bears considerable resemblance in chemical composition to the guano obtained from Saldanha Bay, South Africa, but that it contains less nitrogen and more phosphate than typical Peruvian guano.

It was considered by firms interested in guano that this material from Latham Island could not be profitably exported to the United Kingdom at the present time, on account of the high cost of freight. The pre-war price of such guano in this country was about £3 per ton c.i.f., and even now it would only realise about £8 to £9 per ton.

It may be possible to dispose of the guano in Zanzibar, or a market could perhaps be found for it in East Africa.

Guano represented by the present sample would be of value for manurial purposes, chiefly on account of the satisfactory percentage of available phosphoric anhydride (*i.e.* the portion soluble in a 2 per cent. solution of citric acid). In order, however, to make a complete manure the guano would require to be incorporated with materials containing more potash and nitrogen.

REPORTS BY THE IMPERIAL INSTITUTE COMMITTEE ON TIMBERS

BRITISH COLUMBIA TIMBERS

The Advisory Committee on Timbers have had under consideration the question of the possibility of increasing the sources of supply for this country of softwoods for carcasing and general constructional purposes.

Increasing difficulty in obtaining abundant supplies of timber of this class at satisfactory prices had been experienced for a considerable period before the war, and there can be little doubt that the difficulties will be enhanced during the reconstruction period and subsequently. Hitherto the bulk of the softwoods (pine, spruce and larch) imported into the United Kingdom has been derived from northern Europe, notably Russia and Scandinavia. The proportion furnished by countries of the British Empire has been comparatively small.

It is probable that the softwoods required by this country will continue to be imported in largest part from Europe, but in view of the destruction of valuable forests during the war, and the serious depletion of standing timber in Scandinavia during the last fifteen to twenty years, the situation is uncertain. The Committee have also taken into account the probability that the premier position held by the United Kingdom in the north European timber markets may be affected by the fact that certain countries, hitherto largely self-supporting as regards timber, will be

compelled to enter these markets as competitors with the United Kingdom in consequence of the depletion of their forests for war purposes.

The question of new sources of supply is therefore one of great importance to this country. For many years relatively little assistance can be anticipated from the woodlands of the United Kingdom. Apart from the possibility of obtaining limited supplies of non-coniferous softwoods from certain tropical colonies, the main sources from which new supplies of softwoods are to be looked for are Russia (including Finland) and Canada. In the case of Russia the position is complicated by the political situation. An investigation of the prospects of timber development in this country is outside the scope of the Committee, but it may be mentioned that at the present time Russia would appear to be a negligible factor in the situation. The Committee therefore are of the opinion that the present reconstruction period offers an exceptional opportunity for the Canadian exporter to enter the British market, and that now and subsequently the United Kingdom should look to the Dominion of Canada for a largely increased proportion of her imports of softwoods.

The production of timber in Canada has much increased during the last twenty years, but, owing to the proximity of the market, the greater part of the increased export has been taken by the United States, while the trade with the United Kingdom has remained comparatively small. Canadian timbers, however, are well known in this country, more especially in the northern and western districts, London and the eastern and southern counties being largely supplied with timber from the Baltic.

In this connection the Committee note with interest that arrangements have been made by the British Government for the purchase of a large amount of British Columbia timber (Douglas fir) for use as railway sleepers and for other purposes in this country. The experiment will be watched with much interest by the trade and others.

Reference may here be made to the chief difficulties which hitherto have militated against the success of Canadian timbers in competition with European sorts in this country. (*a*) The most important is *freight*. In the

case of British Columbia timbers this forms a particularly heavy handicap. Roughly speaking, the rates from British Columbia ports (by sailers) to this country before the war were £7 per standard as compared with 32*s*. 6*d*. to 37*s*. 6*d*. per standard from White Sea ports ; 20*s*. to 25*s*. per standard from Baltic ports ; and 35*s*. to 40*s*. per standard from the St. Lawrence. Improved conditions, however, may perhaps be anticipated from the opening of the Panama Canal, and from the building of special ships for the British Columbia timber trade. Further, in spite of the handicap of freight, certain specifications of British Columbia timber have in the past competed successfully with those from Europe, and there would appear to be no special reason why the position should not be improved. (*b*) *Finance and distribution*. Baltic timber is likely to compete successfully with Douglas fir for most purposes, for the following reasons : Baltic timber is sold to the trade in this country in cargoes or parcels through agents here who give the usual facilities, *i.e.* four months' draft. The buyer is able to buy as a rule in the spring, shipments coming in two or three months after purchase. Exporters of Douglas fir labour under the disadvantage that tonnage is not always readily obtainable, and that if obtainable it has to be taken up some months before ship arrives at port of loading.

There is then a four or five months' voyage for the vessel, or if a steamer, six weeks. The demand to be cultivated most is that for square timber, for which article, however, the price is very much regulated by the figures current (cost, freight and insurance) for pitch pine from United States of America Gulf ports. If shippers from Western Canada through their agents will give the usual credit terms current in the wood trade in Europe to buyers of Douglas fir, it would help to diminish the handicap which the distance from Europe naturally puts upon this article. The main difficulty is that the European demand is such a small percentage of the wood that goes through the British Columbia mills, that mill owners have not found it worth while to deviate from the usual terms on the Pacific Coast for the bulk of their business, which is for cash against documents. The Baltic shippers are also well represented

in this country by their own agents, who study closely the requirements of the markets. The Committee understand that in recent years Canadian firms have shown more enterprise in appointing regular agents in this country, and they believe that a wider application of this system would advance the interests of the Western Canadian trade. (*c*) *Condition and Specification.* It is a matter of personal knowledge to members of the Committee that Douglas fir has frequently arrived in this country in poor condition. The defect is chiefly to be attributed to the shipment of unseasoned timber, resulting in discoloration and other faults arising from the length of the voyage. It is most desirable that measures should be taken by Canadian exporters to minimise these defects by proper seasoning before shipment, since in Baltic timber the Canadian product competes with an article of good quality, carefully sorted and in good condition.

The Canadian timbers of commercial importance fall into two groups, viz. those derived from the eastern and east-central provinces, and those from British Columbia. The present report deals with British Columbia timbers. Evidence has been taken from various persons acquainted with timber both in this country and in Canada.

The Committee are of the opinion that the following British Columbia timbers, viz. B.C. Douglas fir, B.C. Tideland (Sitka) spruce and Western hemlock are well adapted to the requirements of consumers in the United Kingdom, and that, if adequate measures are taken to bring them more prominently to the notice of architects, merchants and other users, these timbers are likely to obtain a better position in this market.

The timbers are dealt with in detail below.[1]

1. Douglas Fir (*Pseudotsuga taxifolia*, Britton = *P. Douglasii*, Carr)

This timber (also known as B.C. pine, yellow fir, red fir, etc., and as Oregon pine when obtained from America) is essentially a structural timber suitable for use in this

[1] An article on the distribution, qualities and uses of these timbers, together with the results of mechanical tests, will be found in this Bulletin (1915, **13**, 432).

country as a substitute for American "pitch pine" (its chief competitor in the United Kingdom) and Baltic red fir. It is of special value on account of the large dimensions in which it can be obtained. Baulks 100 feet and over in length and 2 feet square in section can be obtained if necessary. The durability of the timber and its resistance to decay should render it useful for railway cars and sleepers, piling, bridge and trestle timbers, general building purposes and for construction generally.

B.C. Douglas fir is said to be highly valued in western America for railway sleepers, and, as stated above, arrangements have been made for extensive trials for this purpose in this country.

Experience with Douglas fir for wood paving has been gained chiefly in the United States and Canada. Trials on a scale sufficiently large to be of practical value might usefully be carried out in this country with a view to comparing the timber with the European softwoods already in use for this purpose. For successful competition with these latter softwoods, however, it is essential that the Douglas fir should be of satisfactory and uniform quality, regularly available in large quantities and of guaranteed accuracy as regards measurements.

Douglas fir should find a wider application in this country for joinery and general internal work. The timber is stated to make an excellent flooring material when sawn edge-grain, and to wear long and evenly without splintering. On account of its general qualities, strength and ease of working, it should be found suitable for floor beams, rafters and joists; and for doors, sashes and other joinery. As veneers for inside finishing purposes, Douglas fir is also regarded as possessing special qualities, notably the striking grain, hard surface, resistance to warping, shrinking or swelling and its ability to take stains.

The Committee are of the opinion that only the best-quality timber from the coast region should be exported to this country. Timber from the eastern regions of the Province, second-growth timber and that from the very old trees is liable to be coarse-grained and red in colour and is unsuited for export.

Douglas fir usually arrives in this country well seasoned

and in satisfactory qualities, but occasionally "woolly" and wide-ringed pieces are received. The Committee understand that these faults are, if anything, less frequent in B.C. than in American Douglas fir (Oregon pine). More care, however, should be taken in the conversion of the timber, wany edges, faulty sizes, and other defects being avoided. The reported "failures" of B.C. Douglas fir have been due most probably to use of inferior timber.

As regards grading, Douglas fir has hitherto been graded under the rules of the West Coast Lumber Manufacturers' Association (Seattle) under the four classes of "Clears," "Selects," "Merchantable" and "Commons."

2. B. C. Hemlock, Western Hemlock (*Tsuga heterophylla*, Sargent)

This timber has been marketed in Great Britain as western hemlock fir and Prince Albert fir. It is regarded as much superior to eastern hemlock (*Tsuga canadensis*), from which it is distinguished by its straight grain, ease of working and freedom from shake and warp. The wood is nearly white, of fine straight grain, soft, light (32 lb. per cubic foot kiln-dried), stiong, easy to work and of good appearance. It needs paint or preservative when exposed to the weather.

The Committee consider that this timber, though not so strong as Douglas fir, would find a market in this country. It would be found suitable for framing and shelving, and for flooring when cut edge-grain (rift-sawn) and used in dry places. On account of its appearance, smooth and comparatively hard surface, and ability to take paints and stains, it would be useful for interior finishing; it should also be of value for the cabinet trade. On acount of its strength and lightness and capacity for holding nails well, the timber would be useful for boxes and packing cases.

Western hemlock has long been used in Canada for elevators, grain bins and stables, for which it is especially suitable. It is also stated to be satisfactory for marine piling, and has been used in conjunction with Douglas fir in harbour improvements at Toronto, and to a limited extent in bridge and trestle building.

3. B. C. Spruce (*Picea sitchensis*, Trautv. and Mey.)

This timber, also known as Sitka spruce, Tideland spruce, etc., is tough and strong, elastic, light (26 lb. per cubic foot kiln-dried), of straight even grain, non-resinous and does not warp. It is soft and easily worked and when nailed does not split; it takes paints and stains well. B. C. spruce has come into great prominence for aeroplane construction, for which purpose the best qualities are probably unsurpassed. The less expensive qualities should be well suited for many building purposes, *e.g.* framing and shelving; and for sashes, doors, panelling and sink boards. B. C. spruce is well known as a first-class wood for oars and paddles. Its lightness, nailing qualities and absence of taste would make the wood particularly useful for boxes, especially for packing foods.

The timber would also appear to be well adapted for use in the manufacture of piano sounding-boards on account of its straight fine grain and resonant qualities, and the large clear sizes in which it is obtainable.

Usage of British Columbia timbers in the United Kingdom; mechanical tests and practical trials

The advice of the Imperial Institute has been sought by the Forest Products Laboratories of Canada as to the best means of bringing to the notice of architects and others in this country the results of the tests of Canadian timbers carried out by the Forest Products Laboratories. The Committee have advised on this point and made suggestions as to the methods of recording the tests in question. The Committee are also aware of the tests carried out in the United States on American-grown samples of timbers occurring in British Columbia. It was considered desirable, however, to carry out further tests under the conditions obtaining in this country and to conduct corresponding tests with certain European timbers for purposes of comparison.

Arrangements were therefore made for H.M. Office of Works to carry out practical trials and mechanical tests on B.C. Douglas fir, B.C. spruce and B.C. western hemlock, with a view to placing these timbers in the official

specifications of the Office of Works if the results proved satisfactory. The necessary timber for the trials was kindly supplied by the B.C. Government at the request of the Imperial Institute. The practical trials include the construction of articles of joinery, and must necessarily extend over a considerable period of time in order to test the behaviour of the woods in this country. So far, the joinery made from B.C. Douglas fir appears to be quite equal to that made from Petersburg fir.

The mechanical tests were carried out for H.M. Office of Works at the National Physical Laboratory, and for purposes of comparison Petersburg fir, Christiania spruce and English oak were submitted to similar tests.

The general conclusion to be drawn from the tests is that B.C. timbers may be regarded as equal if not superior in strength to European timbers. Assuming the material used in the tests to be representative, it is safe to say that, when used in building construction, B.C. timbers may be from 10 to 15 per cent. smaller in size than corresponding European timbers, taking into account the usual factors of seasoning, grain, knots and general quality.

B. C. Douglas fir, silver spruce and western hemlock are obviously well suited for general construction and other purposes in this country, and if imported in increased quantities and of satisfactory quality would form valuable additions to the supplies of softwoods at present available. The Committee recognise, however, that the extended use of these (and other Canadian timbers) in the United Kingdom depends chiefly upon the prices at which they can be delivered. In this question the determining factor is the cost of freight as compared with timber obtained from the Baltic. The outstanding advantage of British Columbia timber (notably Douglas fir) is the exceptional dimensions in which it can be supplied. The special prices which will be paid for timber of exceptional dimensions will probably enable certain B.C. woods (*e.g.* Douglas fir) to find a market here in spite of high freights; timbers of smaller sizes, however, can be obtained more cheaply from the Baltic. As regards spruce and western hemlock, the position is essentially the same, namely one of price. There will always be a relatively restricted special demand

for best-quality spruce in virtue of its specific qualities, and this demand will probably increase with the growth of the aeroplane industry. For ordinary purposes, however, the use of the wood will be regulated by its cost as compared with Baltic timbers, and it is doubtful if the average and lower grades of the timber can be profitably exported to the United Kingdom.

The Committee are informed that the Great Eastern Railway Co. (among other railway companies) propose to carry out trials with B.C. sleepers which have been obtained by the Railway Executive Committee.

A special exhibit of B.C. timbers and manufactured material prepared by the Forest Branch of the Ministry of Lands of British Columbia is arranged in the Canadian Court at the Imperial Institute. Any enquiries in regard to these timbers will be dealt with.

Further efforts to encourage the development of the export trade in these timbers to the United Kingdom are very desirable. The Committee suggest that among the steps taken there should be action on the part of Canadian shippers to secure the export of well-conditioned timber, fully up to the standard of grade and specification under which it is shipped ; in this connection the Committee consider that the most promising course would be for the facts to be laid before the leading shippers by the Canadian Government. They also suggest action to bring the facts with regard to Canadian timbers more fully to the notice of merchants, architects and others in this country ; in this matter the Committee are prepared to render every assistance.

August 1920.

NIGERIAN TIMBERS

I. First Report on Certain Nigerian Timbers

Fifty-two logs (representing eleven different timbers) were received at the Imperial Institute in 1918 for report by the Advisory Committee on Timbers. The logs were carefully stored, and one log of each timber selected for examination.

The selected logs were cut into planks 2 in. and

4 in. thick respectively, averaging about 12 ft. long, and of the full width of the log. One plank of each timber was artificially seasoned, by the dry steam process, at the works of Messrs. Holliday & Greenwood, Ltd., through the kindness of Mr. James Holliday, a member of the Committee. Control planks are in course of natural seasoning.

The artificial seasoning proved entirely successful in all cases, and the Committee decided to examine the planks so treated, and to submit an interim report. Their report is as follows:

1. Arere (*Triplochiton Johnsoni*, C. H. Wright).—Original width of plank $15\frac{31}{32}$ in.; shrinkage $\frac{1}{32}$ in. A soft wood, which has no special character, and is of no value for building purposes in this country. There would probably be much waste in conversion.

2. Afara (*Terminalia superba*, Engl. and Diels.).—Original width of plank $16\frac{1}{4}$ in.; shrinkage $\frac{1}{16}$ in. Heart-shakes present. A wood very similar to oak in colour, and possessing a straight grain. Would be useful for general joinery work.

3. Ogugu (*Sterculia cordifolia*, Cav.).—Original width of plank $16\frac{1}{4}$ in.; shrinkage nil. This wood is remarkable for the absence of shrinkage in seasoning, but is of no special value for this market.

4. Iroko (*Chlorophora excelsa*, Benth. & Hook. f.).—Original width of plank $20\frac{3}{8}$ in.; shrinkage nil. A very useful wood of good appearance, suitable for joinery and a variety of purposes. Already well known on this market, but its sale should be pushed more than at present.

5. Ekhimi (*Piptadenia africana*, Hook.).—Original width of plank $18\frac{7}{16}$ in.; shrinkage $\frac{1}{4}$ in. This wood resembles plain oak in appearance, but has no specially attractive feature. It might find a market as a cheap furniture wood, but is too heavy for many purposes. It is also suitable for rough construction work, doors, sills, etc., and it might be worth testing for fire-resisting qualities.

6. Obobonekhui (*Guarea Thompsoni*, Sprague & Hutchinson).—Original width of plank $18\frac{7}{16}$ in.; shrinkage $\frac{1}{8}$ in. A wood of good quality, already marketed

in this country as a mahogany, of which it is a good type; the grain is somewhat similar to Honduras mahogany. A better timber than Okwein (which might also sell as a mahogany), being of better colour and milder in working. It might be used for carriage building.

7. ANAMOMILLA (*Lovoa Klaineana*, Pierre).—Original width of plank 14 in.; no shrinkage. Well known on this market as West African walnut, selling at about half the price of West African mahogany. The timber is often darker than the plank examined. Hitherto it has been used chiefly for cheap furniture, and it is difficult to suggest other uses.

8. OKWEIN (*Brachystegia spicæformis*, Benth.).—Original width of plank 12 in.; shrinkage $\frac{1}{16}$ inch. Small shakes present. The wood is light mahogany in colour, but somewhat similar to Iroko in grain though not so hard. It would polish well, and might sell as a mahogany.

9. AINYERAN (*Afrormosia laxiflora*, Harm.).—Original width of plank $16\frac{5}{8}$ in.; shrinkage $\frac{1}{8}$ in. Bad cross-breaks present. Of no value for this market.

10. ALIGNA (*Afzelia africana*, Sm.).—Original width $21\frac{1}{8}$ in.; shrinkage $\frac{3}{16}$ in. A hard wood of light colour and good general character, suitable for solid doors, stair treads and general joinery. It would probably command a price up to that of Iroko.

11. AGBA (*Pterolobium*, sp. ?).—Original width of plank $32\frac{5}{8}$ in.; shrinkage $\frac{1}{4}$ in. A good useful wood of very serviceable width. Resinous. It has no special figure, but would be useful for any cheap cabinet work: plain-polished it would resemble oak. It would also be useful for construction work, sills and treads.

It will be noted that apart from Iroko, Obobonekhui and Anamomilla (which are already known on the market) the most promising timbers are Afara, Ekhimi, Okwein, Aligna and Agba. The Committee, however, are agreed that before any further steps can usefully be taken in regard to marketing these timbers in the United Kingdom, it is essential to obtain from the Nigerian Government information as to the prices at which the timbers can be placed on the market in this country. The Committee

will be glad if such information can be furnished as early as possible.

As regards the timbers recommended by the Committee as suitable for cheap furniture and as substitutes for mahogany it is considered that these woods would sell in this country at from half to two-thirds the price of West African mahogany. Ekhimi would probably fetch from half to two-thirds the price of American oak; the present price of American oak in the log is from 5*s.* to 6*s.* per cubic foot.

Further the Committee are of the opinion that the exploitation of Nigerian timbers other than mahogany would be best effected by Government assistance to approved firms of timber merchants, notably by a reduction of felling dues. The Committee understand that the felling dues on mahogany in Nigeria are 56*s.* per tree, the dues on other trees being 20*s.* per tree. The difference is considerable, but it is doubtful whether it is sufficient to induce timber cutters to fell for export trees other than mahogany. The Committee therefore suggest for consideration that the dues imposed by the Government on these trees might be reduced to 5*s.* per tree for a trial period of say five years, in order to encourage the exploitation of the timbers in question.

July 1919.

II. Second Report on Certain Nigerian Timbers

In response to the request made in their first Report, the Committee have been furnished by the Government of Nigeria with the estimated prices, f.o.b. Nigeria (February 1920), of squared logs of the five species of timber referred to in the interim Report.

The information supplied to the Committee is as follows:

Name of timber.	Price f.o.b. Nigeria (February 1920).
Afara (*Terminalia superba*)	1*s.* 6*d.* per cubic foot
Ekhimi (*Piptadenia africana*)	3*s.* 3*d.* ,, ,, ,,
Okwein (*Brachystegia spicæformis*)	2*s.* 6*d.* ,, ,, ,,
Aligna (*Afzelia africana*)	3*s.* 6*d.* ,, ,, ,,
Agba (*Pterolobium* sp.)	2*s.* 0*d.* ,, ,, ,,

Round logs of either floating or sinking timber exploited within reasonable distance of navigable waterways would be cheaper than squared logs.

The Committee have carefully considered the bearing of this information upon the question of the commercial export to this country of the timbers in question, and have reached the following conclusions. The Committee confirm their views as to the technical qualities of the woods as stated in their first report.

At the time of receipt of the information as to prices, market conditions in this country were such that, except in the case of Ekhimi, there was good reason for believing that all the timbers recommended by the Committee would find a market in the United Kingdom at the prices mentioned by the Government of Nigeria, allowance being made for freight and other charges. The Committee considered that *Afara* (1*s.* 6*d.* per cubic foot) would be saleable in this country if available for regular export in commercial quantities and shipped in sound condition. *Aligna* (3*s.* 6*d.* per cubic foot) appeared to be expensive, but in view of the enhanced prices of mahogany (with which Aligna would probably compete) obtaining at the time, the Committee were of opinion that this timber would probably find a sale in this country. *Ekhimi* (3*s.* 3*d.* per cubic foot) would be useful for cheap furniture and rough construction purposes, but at the price mentioned would be too expensive for such purposes in this market.

More recently, however, there has been a marked decline in the prices obtained in this country for defective and lower grades of West African mahoganies, with which the timbers under consideration would probably be classified, and the Committee regret that, with the lower values at present ruling, it would not be possible to find a market in the United Kingdom for the timbers at the prices quoted by the Nigerian Government, plus present cost of freight and other charges. It is evident, however, that prices in the timber market are still unstable, and it is not impossible that conditions in the future may offer prospects for the successful introduction of these woods into the United Kingdom, more especially if there should be a fall in freight charges, which are the deciding factor.

The situation will be carefully watched by the Committee with a view to action being taken at a favourable opportunity.

August 1920.

III. Sapele Mahogany

The timber forming the subject of this report was cut from a tree felled in 1917, which had been ring-barked in 1914 by Messrs. Miller Bros. (of Liverpool), Ltd., with a view to ascertaining whether Sapele mahogany subjected to this treatment would be free from the ring-shakes which hitherto have characterised Sapele mahogany, to its detriment in the English market. Before the war this timber was marketed principally in Hamburg.

Five logs in all were shipped to this country by Messrs. Miller Bros. Four logs were retained by the firm ; the fifth log was assigned to the Imperial Institute, and was submitted to the Advisory Committee on Timbers for report.

At the instance of the Committee the log was cut into boards (varying in thickness from 2 in. to ½ in.) by Messrs. Robert Bruce & Co., Liverpool, who also sent to the Committee, for purposes of comparison, samples including a small plank cut from a Sapele tree which had not been ring-barked.

On arrival at the Imperial Institute in July 1918 the boards were " stuck " in a dry place to allow of satisfactory seasoning. By February 1919 the boards were sufficiently seasoned to warrant examination by the Committee, and have since been kept under observation. Through the kindness of Mr. James S. Holliday, a member of the Committee, arrangements were made for the seasoning of a representative sample of the timber to be completed by the artificial seasoning process (dry steam) adopted by Messrs. Holliday & Greenwood, Ltd., London ; and also for working trials, including polishing, to be carried out by the same firm. The Committee are much indebted to Mr. Holliday for his assistance in this matter.

The board selected for this purpose measured 4 ft. long by 2 ft. wide by ½ in. thick, and was free from

warp. On the completion of the artificial seasoning the board was planed, and allowed to stand aside for several months exposed to the changing conditions of temperature of a works office. It was then dressed and polished, and submitted to the Committee together with a statement by Messrs. Holliday & Greenwood, Ltd., as to its working qualities.

The results of the Committee's investigations are as follows :

The ring-barked log of Sapele mahogany supplied to the Committee showed no trace of ring-shake. While from a single instance it would be unwise to regard the absence of ring-shake as the direct result of ringing the tree before felling, it is interesting to note that the other four logs retained by Messrs. Miller Bros., also from ring-barked trees, are reported by Messrs. Robert Bruce & Co. to have showed no external signs of ring-shake. Nevertheless, the Committee are of the opinion that the results, though promising, do not justify the conclusion that ring-barking can be entirely relied upon to prevent ring-shake, which in their experience is most difficult completely to avoid in certain trees. Ring-shake frequently occurs in the tree before it is felled, and the actual cause of the defect is not fully understood. It appears, however, that the practice of ring-barking may be a desirable one.

The suggestion that ring-shake may not occur in young Sapele trees is worth investigation, and the Committee propose to request the Nigerian Government to allow Messrs. Miller Bros. to fell six young trees not exceeding 24 inches in diameter, in order to investigate this point.

The boards cut from the log examined by the Committee showed no signs of checking, except in one or two cases. They exhibited no apparent difference in colour or quality as compared with the sample of Sapele mahogany felled without previous ring-barking which had been sent to them by Messrs. Robert Bruce & Co. for comparison. A number of the planks, however, exhibited the well-known warping to which this timber is subject. As regards this defect the Committee point out that warping in Sapele mahogany has been avoided on the Continent by sawing the log on the quarter, and they are of the opinion that

such treatment affords the only means of preventing the ultimate appearance of the defect in question.

The artificial seasoning trial to which the timber was subjected by Messrs. Holliday & Greenwood, Ltd., was entirely satisfactory.

As regards the working trials the behaviour of the wood under machine and hand tools was similar to that of other African mahoganies of good class. In sawing, however, care must be taken to avoid too rapid cutting or the cut faces may be concave. The wood takes a fine finish and polishes well. When finished and allowed to stand for four months the plank showed no perceptible tendency to change its shape, but it has since warped. A small shake purposely admitted in the sample has not further developed down to the present time.

The sample was found to be of good figure, even grain and fairly close texture. The appearance and character of the wood render it very suitable for high-class joinery and fittings.

April 1920.

IV. Mangrove Wood (*Rhizophora racemosa*, E. Mey.)

The question of the possible utilisation in this country of mangrove wood (*Rhizophora racemosa*, E. Mey.) from Nigeria has received the careful consideration of the Advisory Committee on Timbers.

The timber examined by the Committee was furnished to the Imperial Institute by the Government of Nigeria and by Messrs. Miller Bros. (of Liverpool), Ltd., and consisted of baulks (in the form of sleepers) and logs.

Nigerian mangrove timber varies from dark red to yellowish red, and is very hard, of close texture, gummy and brittle. It is difficult and expensive to work, and possesses no specially attractive characters. The sapwood is about 1 in. to 1½ in. thick and pale coloured. The trees are stated to be very plentiful, growing in pure forest in the mud of the deltas of the Niger and Cross Rivers where the water is brackish.

A marked feature of the wood examined by the Committee was the tendency to split and check to an extent

which rendered the timber of little use for practical purposes. Arrangements were therefore made with Messrs. Miller Bros. (of Liverpool), Ltd., in 1917, to carry out a series of experiments with the wood in Nigeria, with a view to ascertaining whether these defects can be avoided by proper methods of seasoning. The experiments were kindly undertaken by Messrs. Miller Bros., with the trees growing near Koko (Benin district) :

1. Six trees (yielding twelve logs) were felled on November 23, 1917. From six logs the bark was removed ; the remaining six logs retained the bark. All twelve logs were placed under cover, with free ventilation, and seasoned for fifteen months, when they were shipped to the Imperial Institute for examination.

2. Six trees (yielding twelve logs) were ring-barked on November 19, 1917. Three trees (six logs) were felled about a year later and shipped to the Imperial Institute. The remaining trees (six logs) were felled in March 1919, and from three logs the bark was removed. These six logs were seasoned under cover and shipped to the Imperial Institute in May 1920.

The logs have been carefully examined by the Committee, who consider that the results of the experiments show that advantage accrues from the careful seasoning of mangrove timber. All the logs exhibited star-shakes at the ends, but in no case was the surface of the logs affected, and it is not improbable that the shakes penetrated to a comparatively short depth into the log. The star-shakes in the logs ring-barked before felling were more serious than those in the logs not so dealt with, and in this respect therefore no advantage would appear to result from ring-barking mangrove trees before felling.

The Committee have considered carefully the suitability of mangrove wood for use in this country, but apart from a possible use as railway sleepers there would appear to be little or no prospect of the wood successfully entering the English market. The marked tendency to split and check unless carefully seasoned, the absence of any special "character," and the difficulty and expense of working render the wood of no value for the furniture and cabinet trades. In constructional work the timber

would be useless for general carcassing purposes on account of its weight and working qualities, but might be serviceable locally for heavy rough construction work if obtainable in sufficiently large sizes.

As regards railway sleepers the Committee have made enquiry of the Anglo-French Timber Company, who are extracting the timber in Nigeria, and are informed that the wood has been supplied to the French and other Continental State Railways as half-round sleepers.

Enquiry was therefore made of the Railway Executive Committee (Board of Trade) as to the possibility of half-round sleepers being accepted for use on British railways. The Railway Executive Committee replied that such sleepers could not be utilised on British railways since they do not conform to the standard specification for sleepers which has been adopted in this country. An abstract of essential features of the specification forms an Appendix to this report. Further enquiries showed that the Anglo-French Timber Company were not in a position to supply mangrove sleepers of the size and shape required.

The Committee, however, consider that carefully seasoned mangrove sleepers, if conforming in all respects with the official specification, would be worth trial in this country. They would be glad to be informed of the prospects of obtaining such sleepers in Nigeria, the quantities annually available for export, and the price (f.o.b. Nigeria) at which they could be shipped.

To obtain the best results the sleepers should be cut from trees recently felled, and stacked with air-spaces between them. They should be protected from the sun during seasoning.

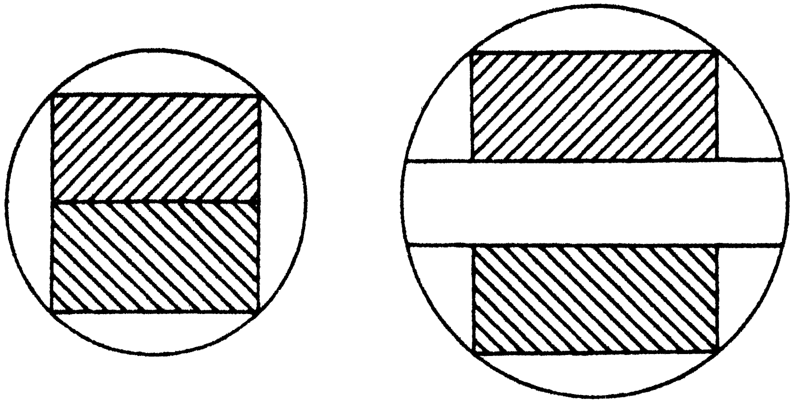
August 1920.

Appendix

Extracts from Specification for Railway Sleepers for use on British Railways

Sleepers shall not be more than 9 ft. 3 in. or less than 8 ft. 11 in. long, 10 in. wide, and 5 in. thick. They must not vary in width or thickness from the dimensions

specified by more than ¼ in., and shall be sawn from logs as shown on the diagrams below.



Sleepers containing the heart more than 1 in. in from the 10 in. face will not be accepted.

Not more than 25 per cent. of the total number in each cargo may have a wane not exceeding 1 in. on each edge of one face of the sleeper. The sleepers must be rectangular in section, with square ends. They must be straight in grain, and made from growing trees. They must be sound and free from bark, gum veins, shakes, splits, large, loose or decayed knots, or any imperfections liable to affect their strength and durability.

GENERAL ARTICLES

THE CULTIVATION OF THE AFRICAN OIL PALM, WITH SPECIAL REFERENCE TO THE EAST INDIES

Much attention has been given at the Imperial Institute to the West African oil palm (*Elaeis guineensis*), more particularly with a view to the improvement of the methods of preparing palm oil and kernels in West Africa. On the initiative of the Director of the Imperial Institute, systematic investigations were made in the British West African Colonies by the Inspector of Agriculture for West Africa in the first instance, and by officers attached to the local Forestry and Agricultural Departments. The large

amount of new information collected in the course of this enquiry was incorporated in an article in this BULLETIN (1909, **7**, 357), which also contained the results of examination at the Imperial Institute of the fruits of a large number of varieties of oil palm occurring in the Gold Coast and Nigeria. Particulars of later investigations of palm fruits from these and other parts of Africa were given in a later number (1913, **11**, 206). One of the chief factors in relation to the working of the wild trees in West Africa is the provision of suitable machinery for preparing palm oil, and for cracking palm nuts in order to obtain the kernels for export. A detailed discussion of this problem, with a description of the various machines and processes available, was given in this BULLETIN (1917, **15**, 57). The bulk of the palm oil produced in West Africa is still prepared by the natives by primitive methods, resulting often in the production of a low grade of oil. The kernels are still mainly obtained by cracking the nuts by hand, involving a large waste of labour. Owing to the great demand for fats of all kinds at the present time, and the fact that palm oil of good quality can be used after proper treatment for the preparation of edible fats, considerable attention is now being given to the question of cultivating the tree, not only in Africa, but in other tropical countries. It is recognised that, by growing the palm under plantation conditions, it is possible to control the preparation of palm oil to much greater advantage. The fruits gathered from a plantation can be treated at a central oil factory without the delay that is frequently involved in dealing with the produce of wild trees, and this is a factor of prime importance, as freshly gathered fruits yield an oil of much better quality than that obtained from fruits which have had time to ferment. Moreover, the experience gained in Malaya and Sumatra indicates that cultivated palms produce a much larger yield of fruits than the wild trees of West Africa.

In view of the great interest now being shown in the subject, the present article has been prepared, dealing with the main features in the cultivation of the oil palm. The plantation industry is at present in its infancy, and practical experience in cultivation on a commercial scale

is almost wanting. The only large areas of cultivated palms in bearing are in the Dutch East Indies, and much useful information has been obtained from companies concerned and from two papers published by Dr. A. A. L. Rutgers, Director of the General Experiment Station of the Algemeene Vereeniging van Rubberplanters ter Oostkust van Sumatra, in the *Mededeelingen* of that station (*Algemeene Serie*, No. 6, 1919, and No. 8,1920), dealing with observations on the oil palm in Sumatra.

Distribution of Oil Palm in West Africa and Exports of Products

The oil palm has a wide latitudinal range in West Africa, viz. from about 16° N. to 12° S., occurring, that is, both in the equable and constantly moist climate of the equatorial zone and in the contrasting climate of the tropics ; but the trees are far more luxuriant and productive in the former regions. Along the west coast the palm extends from the Gambia to Angola, and, although generally confined to a coast-belt less than 300 miles wide, it is common round the villages throughout the forest region of the Middle Congo to the southern frontier of Wadai, Ubangi, the Upper White Nile and Albert Nyanza, and in the Belgian Congo to the north and north-east shores of Lake Tanganyika, on the Zambesi, and as far south as Bandawe on the west shore of Lake Nyasa. In East Africa the oil palm occurs in Uganda, Tanganyika and Zanzibar, where, however, it is less common and productive than on the west coast.

With the exception of small quantities produced in Sumatra, all the palm oil and kernels of commerce are derived from West Africa, by far the most important producing country being Nigeria. Other countries which contribute largely to the world's supply are Sierra Leone, Gold Coast, Belgian Congo, Dahomey, Ivory Coast, Togoland, Cameroons and Portuguese Guinea, whilst smaller quantities come from Angola, the Gambia, and the French colonies of Senegal, Guinea, Middle Congo and Gaboon. Before the war most of the palm kernels were shipped to Germany, but a large palm-kernel crushing industry

developed in the United Kingdom during the war, and this country now takes the bulk of the world's supplies, although most of the produce of the French West African possessions is exported to France. The United Kingdom is also the chief customer for palm oil.

The available figures of exports of palm oil and kernels from the chief West African countries during 1913–18 are shown in the following tables:

Exports of Palm Oil

	1913. Tons.	1914. Tons.	1915. Tons.	1916. Tons.	1917. Tons.	1918. Tons.
Nigeria	83,089	72,531	72,994	67,422	74,619	86,425
Gold Coast	3,542	2,042	1,363	1,855	819	2,764
Sierra Leone	2,542	1,796	1,983	2,297	2,238	1,073
Dahomey	7,845	6,516	9,443	12,430	11,620	7,979
Ivory Coast	5,919	4,240	4,904	6,839	6,144	3,118
Belgian Congo	1,942	2,458	3,354	3,790	5,321	—
Togoland	1,155	—	—	920	1,477	—
Cameroons	3,537[1]	—	—	—	—	—
Other countries[2]	300	200	400	400	400	400

[1] *Exports in* 1912, *later figures not available.* [2] *Estimated.*

Exports of Palm Kernels

	1913. Tons.	1914. Tons.	1915. Tons.	1916. Tons.	1917. Tons.	1918. Tons.
Nigeria	174,718	162,451	153,320	161,439	185,998	205,167
Sierra Leone	49,201	35,915	39,624	45,316	58,020	40,816
Gold Coast	9,744	5,633	4,064	5,857	4,768	8,933
Gambia	545	494	326	664	532	644
Dahomey	25,900	20,900	22,800	28,000	16,700	25,000
Ivory Coast	6,840	5,560	6,010	7,830	6,030	6,400
Guinea	5,090	4,650	5,740	5,865	6,960	3,350
Senegal	1,870	1,480	1,690	1,400	4,000	1,580
Middle Congo	½ cwt.	160	550	2,370	5,266	—
Gaboon	565	796	599	1,549	—	—
Belgian Congo	7,080	7,920	10,590	22,030	34,480	—
Togoland	7,025	—	—	8,075	8,192	—
Cameroons	15,742[1]	—	—	—	—	—
Portuguese Guinea	6,520	5,400	4,670	2,820	11,021	—
Angola	3,760	—	—	—	—	—

[1] *Exports in* 1912, *later figures not available.*

The most striking feature in the above tables is the continual rise in the exports of palm kernels from Nigeria during the war; in 1919 they showed a still further rise to 216,913 tons. The exports of palm oil from Nigeria fell slightly in 1914, but were steady until 1918, when there was a rise to over 86,000 tons, whilst in 1919 they amounted to over 100,000 tons. Another interesting

feature brought out in the second table is the rapid increase in the exports of palm kernels from the Belgian Congo, a result due in the main to the enterprise of an English firm. Since the war Dahomey has increased greatly its output of kernels, the exports in 1919 amounting to 68,000 tons. The total annual exports from West Africa at the present time may be taken to be about 130,000 tons of palm oil, and 400,000 tons of palm kernels.

The only country in West Africa where palm kernel oil is produced for export is Nigeria. In 1915, the exports were 13 tons, but no further trade seems to have been done until 1919, when 3,356 tons were exported.

Position of Oil Palm Cultivation in Various Countries

Comparatively little has been done hitherto in regard to the cultivation of the oil palm in plantations in West Africa, although within the last year or two the question of planting the palm on a large scale has been considered seriously, particularly in the French possessions. There are plantations at Gazi, in the Belgian Congo; in the Cameroons, where 4,118 acres were in bearing in 1912 (cf. this Bulletin, 1915, **13**, 403); and in San Thomé, where the palm is commonly planted as shade for cocoa. It is likely, however, that, in view of possible serious competition from the East Indies, more attention will be paid in the future to the care of the wild palms, by which means alone the production could be greatly increased. The mere thinning of the trees and the clearing of the undergrowth for two or three yards round each of them to facilitate the collection of the fruit increases the production of cones. At the Peki Blengo Agricultural Substation in the Gold Coast, 398 palms on a 5-acre plot cleared by cutlassing, but not under soil cultivation, the stems being "dressed," gave 171 bunches of fruit weighing 3,222 lb. in 1915. In 1916, 357 trees on the same area gave 223 bunches, weighing 4,355 lb. In 1917, the trees, having been thinned to 327, gave 534 bunches, weighing 12,639 lb. In 1918, the trees, having been further thinned to 281, gave 629 bunches, weighing

17,790 lb. Scattered oil palms on cultivated ground at the same station gave 805 bunches weighing 13,071 lb. in 1916, 1,248 bunches weighing 27,758 lb. in 1917, and 1,456 bunches weighing 36,736 lb. in 1918, although a good many trees had been removed in the last-mentioned year. These figures show the advantages of clearing, dressing and thinning the palms. It has been stated that it is no exaggeration to say that the yield of oil may be doubled in the first year, and increased fourfold in three or four years of careful treatment (Van Pelt, *Bull. des Mat. grasses, Marseille*, No. 6, 1919, p. 221). In some parts of West Africa, in addition to the long-practised treatment of wild palms by clearing the undergrowth—too often by means of fire—and dressing the stems, there are already extensive uninterrupted stands of Elaeis which are in some cases as carefully tended as the olive gardens of the Mediterranean. The Bonbouris on the Ivory Coast sow handfuls of palm nuts on their newly made clearings, and the Baoulis have taken measures to increase the area under oil palms, whilst in parts of the Southern Provinces of Nigeria, Lagos and Lower Dahomey there are such plantations as are here alluded to.

The Government of the Gaboon have suggested that ten trees might be required to be dressed for every adult in a native village, clearing the stems of two trees being reckoned as a day's work (*Bull. des Mat. grasses, Marseille*, No. 1, 1917, p. 7), and that not more than 200 palms should be left on a hectare (80 per acre); but in Abomey each village has been ordered to establish a nursery containing twelve palms per head of the population. As M. Chevalier points out, this would be a most interesting experiment if these nurseries were stocked with selected seed; but the natives will almost certainly merely follow their usual practice of transplanting chance forest seedlings. What is required is thorough seed selection, and this can only be effected in nurseries under conscientious European supervision, which must probably be that of the agricultural administration.

The most favourable localities outside West Africa for the cultivation of the oil palm are, so far as present experience shows, Malaya and Sumatra. In both countries

the tree has proved remarkably precocious, yielding large quantities of fruit at a much earlier age than is the case in West Africa. This may be due, however, rather to the effects of cultivation than to a more suitable climate.

Fauconnier (*Bull. des Mat. grasses, Marseille*, No. 1, 1920, p. 20) has given an interesting account of his experiences with the oil palm on a rubber estate at Rantan Panjang, near Kuala Lumpur in Selangor. Selected seed was imported from Sumatra in 1912 and sown in nurseries. The seedlings were planted out in May 1913, and many of the trees bore fruit at three years, and were in full bearing in their fifth year. Fauconnier estimates that the average yield per tree per annum is twelve bunches each weighing 8 kilograms (17·6 lb.). This is much above the average given by West African palms. Many of the bunches actually weighed 30 kilograms (66 lb.) while some even attained a weight of 62 kilograms (136 lb.). The soil on which they were growing was only of average fertility, and no manure had been applied since the trees were planted. Coconuts planted on the same soil in 1910 had not yielded fruit at the time the observations on the oil palm were made.

The oil palm has been also planted with success on a small scale in Malacca.

The Director of Agriculture, Federated Malay States, in his *Report* for 1919, states that "several large areas have been taken up for the purpose of growing the palm on a commercial scale. . . . The Governments of the four States [Perak, Selangor, Negri Sembilan and Pahang] are reserving large areas of land exclusively for this crop, and land will be given out on specially favourable terms."

As already mentioned, the oil palm is cultivated on a large scale on modern lines in the Dutch East Indies. The east coast of Sumatra is the chief centre of this industry, although there are plantations in Attjeh and in the western part of Borneo. The oldest plantations in Sumatra date from 1912, but there are older trees planted in avenues in various parts (see p. 242). The total area planted in the east coast of Sumatra in 1918 was 4,380 hectares (10,800 acres), and in 1919 5,200 hectares (12,800 acres), of which 2,800 hectares (6,900

acres) were in bearing. The crop has not yet been utilised to the fullest extent, owing to the difficulty of obtaining the necessary machinery from Europe, but in 1919 570 tons of palm oil were produced.

The trees in Sumatra do not appear to come into bearing quite so early as in Malaya; on the average, fruiting commences at the end of the fifth year, but in some cases the palms bear a good crop in the fourth year. The yields are excellent, as shown in a later section of this article (p. 245).

Oil palms of various ages exist in Indo-China, but according to Chevalier (*Bulletin. Econ. Indo-Chine*, 1918, **21**, 302) they are not well cared for, and give only moderate yields of fruit. Fauconnier (*Bull. des Mat. grasses, Marseille*, No. 1, 1920, p. 23) states that several hundred young palms from Malaya were planted in the north of Cochin-China in 1915. Their growth there is normal, but whether they will yield well is not yet decided. The climate of Indo-China is tropical, with well-defined rainy and dry seasons, and, by analogy with the conditions obtaining in West Africa, it seems likely that the yield will not be so good as in Malaya, where the climate is equatorial, and long dry periods are unknown.

In the Seychelles the conditions seem particularly favourable to the growth of the oil palm. Plants set out at the Botanic Gardens in January 1915 produced small bunches of fruit in January 1917, whilst older, isolated trees sometimes give very large yields. Numerous small plots have been planted out on the Crown Lands, and it is recommended that the oil palm should be planted on an extensive scale in the islands as an adjunct to the coconut palm, which is so much handicapped by diseases.

Oil palms planted for ornamental purposes in Ceylon appear to have grown well, and experiments have been conducted in recent years in order to ascertain the suitability of the country for the cultivation of the tree as a source of oil. Seeds of the "Abe pa" variety from the Gold Coast were sown in 1915, and in November of the same year the seedlings were planted 22½ ft. apart each way on three acres of land at the Dry Zone Experiment Station at Anuradhapura. Cow-peas were sown between

the trees, and ploughed in periodically as a green manure. The plants were irrigated during the dry season, and bore fruit in 1918. Samples of the nuts produced in that year, and in 1919, have been examined at the Imperial Institute. They proved to be of the ordinary thick-shelled variety, and gave a normal yield of oil. A detailed report on these nuts is given on p. 167. In view of the fact that irrigation is necessary during the dry season at Anuradhapura, it seems doubtful whether the cultivation of the oil palm would prove profitable in that part of Ceylon, in competition with countries like Malaya and Sumatra, where the climate is more favourable.

The oil palm has been introduced into the tropics of the New World. Large quantities of seed have been imported into British Guiana from West Africa, but their germination was very poor; 700 young plants were distributed for cultivation at various Government Experiment Stations and Farms in the Colony in 1914–15, but it is too early yet to pronounce an opinion as to whether the palm will succeed in that country. The tree was introduced into Brazil many years ago, and has become quite acclimatised in many parts. It does particularly well in the Amazon Valley, and this region may, in the future, become an important source of oil palm products.

Description of the Oil Palm and its Chief Varieties

Root-system

The seedling oil palm has a vertical tap-root. This, however, dries up at an early stage, leaving a flat surface on which four to six rows of lateral branching roots are developed. These become successively longer, ultimately penetrating the soil to a depth of 2 ft. or more, and the outer roots, dying, form a bulky mass of dry, tough, brown strands which constitutes an efficient anchorage for the tree, enabling it to withstand considerable hurricanes. Roots also originate on the lower part of the stem, especially where annual inundation occurs. While only the central roots of the mass are living, the spaces between the outer ones become filled with humus or form a system

of capillary tubes conserving so much moisture as even to benefit interplanted cocoa plants during a six months' drought. The roots are repeatedly branched and become much intertwined, and can sometimes be traced horizontally to a distance of as much as 35 feet from the base of the stem.

Stem

As is the case with many palms, the growth of the stem is at first very slow, a seedling in good deep garden soil being described as only 8 in. high three and a half years after its germination, although bearing more than a dozen leaves, each over 6 ft. long, and beginning to flower. Palms 4 to 5 years old are 12 to 18 in. high; those 7 to 8 years old, about 4½ ft.; those 10 years old, 8 to 10 ft.; 12 years old, 10 to 12 ft.; and 15 years old, 13 to 14 ft.; up to this age, therefore, the trees are quite capable of having their fruiting cones collected by the use of a light ladder without the necessity of climbing. The stem may acquire its maximum girth of 24 to 30 in. or rarely 50 in. at a very early age, and remains practically cylindrical throughout. During the earlier stages of its growth it is covered with bent-over dead leaves which break off or decay, leaving the leaf-bases still adherent to the stem, their axils forming pockets for rain-water, dust, decaying flower-heads and other humus, epiphytic ferns, figs, orchids and other plants (including sprouting nuts from the palm itself), termites, beetles and other pests. The epiphytic figs sometimes send down roots to the ground, enclose the entire palm in a sort of cage and gradually strangle it. The leaf-bases are gradually destroyed by the weather or by insects, and do not disarticulate; but when between 13 and 20 years of age the stem generally becomes clear of all this surface débris (cf. Plate I), when it appears of a blackish colour, either smooth or marked with the lozenge-shaped scars of the fallen leaves. Deep longitudinal grooves sometimes seen in the stem may be due to insect injury to the terminal bud, as may also the very rare cases in which branching of the stem occurs. A variety known as "aroumé" on the Ivory Coast is described as having permanently persistent leaf-stalks.

PLATE I

An oil palm forest in Sierra Leone.

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It is said to yield little oil, but an abundance of sap which is tapped for wine, and the persistence of the leaf-bases may be induced by the tapping.

Leaves

The first two leaves of the seedling palm, which are wrapped round by the cotyledon, are reduced to small leaf-sheaths; and the next 4 or 5 produced are undivided erect leaves with a sheathing stalk 2 to 5 in. long, and a linear-lanceolate blade 4 to 12 in. long, and $\frac{3}{8}$ to $1\frac{1}{2}$ in. wide, recalling the adult leaf of the rum palm (*Borassus*) which is probably the ancestral type of the *Cocoineae*, the tribe to which *Elaeis* belongs. Subsequently formed leaves present transitional forms, with one or two pairs of rudimentary leaflets on the lower part of the stalk; and in those of the second year the terminal lobe is much smaller, whilst in later years it is entirely lost. In the third year the leaves may be 5 to 6 ft. long, with 35 to 60 pairs of leaflets in addition to the spines on the leaf-stalk which represent others; but it is not till the sixth or eighth year that the full dimensions are reached. The palm will then have a crown of 20 to 40 leaves, each 8 to 16 ft. long. The leaves are produced in alternating whorls or cycles of three, each cycle corresponding to about eighteen months' growth. The young leaves emerge as pale green, lance-like, sharp-pointed spikes rising from the centre of the crown, their main axis (rachis) being covered at this stage with ash-grey scales. They gradually unfold 100 to 160 pairs of leaflets and arch outwards. The leaflets are linear-lanceolate, 1 to $1\frac{1}{2}$ ft. or even 4 ft. long and sharp-pointed; and below them the leaf has a stalk (petiole) 1 to 4 ft. in length and 4 to 8 in. wide. This stalk is convex and is often covered with white down on its under-surface and yellowish-green above, with 50 to 60 pairs of marginal spines, which distinguish *Elaeis* from all other African palms, and a mass of intercrossing brown piassava fibres at its base. In high, dry situations the leaves are fewer, smaller and of a lighter green. The leaves are sometimes cut by the natives for thatch, the leaf-stalks being also used in building, and the outer leaves are commonly

removed from low-growing palms on cultivated land to prevent them from overshadowing the crop. When these leaves are still green this is clearly detrimental to the general vigour of the tree. The natives sometimes burn off the dead leaves and epiphytes to facilitate climbing, and even maintain that the burning of the brushwood during the dry season is necessary in order to make the wild oil palms fruit. This latter practice, however, is really only adopted in order to save the trouble of clearing with the axe: it destroys the seedling palms, scorches and seriously damages many of the older trees, and on the whole certainly diminishes production.

Flowering

The oil palms are monœcious, male and female spadices occurring on the same tree but at different levels and periods. Young trees generally bear male cones exclusively for the first year or two of flowering, *i.e.* usually in the third to the fifth or sixth year of the life of the seedling; and it is said that in Dahomey many trees remain exclusively male. In subsequent years the male inflorescences develop some weeks or even months in advance of the female. They originate in the axils of younger leaves than the female cones, generally a series of whorls producing from 9 to 15; and each is borne on a stout, erect, compressed stalk (peduncle), 2 to 8 in. long, with a girth of about 5 in. at the base, and a downy surface and adpressed, pointed bracts (see Plate III, fig. 2). Each spadix is at first enclosed in a sheath (spathe) of two boat-shaped leathery leaves 4 to 12 in. long, which is flocculent externally, and becomes brown and dry when the pollen is ripe. The spadix itself is an ovoid mass 6 to 10 in. long, made up of 75 to 200 erect flower-spikes arranged spirally, and forming 18 to 20 vertical rows. Each spike is 4 to 8 in. long, and terminates in a stout spine, whilst it bears an immense number of minute staminate flowers each covered at first by a bract. The flower consists of six scarious perianth-leaves (sepals and petals) and six stamens united into a tube below. Although these male spadices mature in succession, and produce an enormous quantity of pollen, they have discharged it all before the female

flowers have reached the recipient stage, while the latter will be well advanced in the growth of their fruit before the next series of male flowers mature. The pollen is slightly agglutinated, and both male and female blossoms give off a faint smell, the same in both sexes, which has been variously described as resembling orris-root or anise. Pollination by gravitation, which would seem to be provided for by the relative position of the male and female inflorescences, is apparently impossible owing to the great difference in the time of maturation of the two sexes ; and the agglutinated pollen suggests that wind is not the sole or main agency. The flowers are visited at night by numerous weevils, and insect-pollination may be essential ; but, whether wind or insects be the pollinating agent, pollination will seldom, if ever, be effected by pollen from the same tree. Artificial pollination is, therefore, essential if true-bred seed of the more valuable varieties is to be obtained. This need not, however, be a difficult proceeding. In Tunis it is often carried out by children in the case of the date-palm, the child climbing the palm when the female spadix begins to emerge from its spathe, placing a male spike gathered when just ripe within the spathe, and tying up the latter for 6 to 10 weeks. It would be easy to do the same for oil-palms when not yet tall enough to necessitate climbing ; but, as in this case the spathe perishes at an early stage, paper-bags or banana-leaves would have to be employed to keep off foreign pollen. In Sumatra many of the female flowers fail to set fruit owing to imperfect pollination, and it has been suggested by Rutgers that artificial pollination may, in the future, play an important part in the oil palm industry. After discharging their pollen, the male inflorescences wither and decay, contributing to the accumulation of humus in the leaf-axils that supports the abundant epiphytic vegetation.

The female spadices are borne on shorter and much thicker stalks, and become more massive and nearly spherical in form, measuring about a foot across. The main axis bears from 100 to 240 spikes arranged in a spiral making 8 to 12 turns, and forming 10 to 12 vertical rows. Each spike bears from 5 to 40 flowers, but

ordinarily from 8 to 12, and terminates in a long, stout spine covered with very minute brownish scales. Each flower (which is much larger than the staminate flowers) is in the axil of a yellowish or greenish bract with a long, tapering point; has a six-leaved perianth, as in the male, and an ovary usually of three, but occasionally of four, united carpels, one-chambered and surmounted by three (or four) divergent and recurving stigmas. There is usually only one ovule, which fills the cavity of the ovary; but there may exceptionally be three or four chambers to the ovary, each containing an ovule. The unripe fruits are thus protected by an array of spines from the depredations of monkeys, squirrels, parrots and hornbills; but some of the flowers are also apparently too closely enclosed for pollination. In this case, however, the ovary may enlarge, form a considerable amount of oil, redden and ripen, though destitute of endocarp (shell) and of seed (kernel). Of the several thousand flowers in one female spadix (the *régime* of French writers), not more than 600 to 1,200 will usually develop into normal fruits; and, especially if the compressing leaf-base is not cut away, these will vary very much in size and shape.

Fruit

The enormous number of fruits that may be produced in a single bunch is shown in Plate II.

Six months generally elapse between pollination and the ripening of any one fruit; and, owing to the successive development of the fruiting cones, the ripening of the fruit of a tree will extend over two to six months, although the fruits on one cone ripen nearly simultaneously. In ripening the fruits become broader, and sometimes angular from mutual pressure, being ultimately more or less oval, closely embraced by the slightly adherent perianth, but with a slight basal depression (umbilicus), and often retaining the withered remains of the stigma at the apex. They vary in length from $\frac{5}{8}$ to $1\frac{3}{4}$ in., and in weight from 3 to 25 grams; the average weight in Dahomey is about 6 grams. In structure the fruit, like that of the coconut, is a syncarpous drupe. It has a smooth outer skin or epicarp, which is much cutinised

PLATE II

Fig 1 —Oil palm, Sumatra, fruit bunch weighing 80 lb.

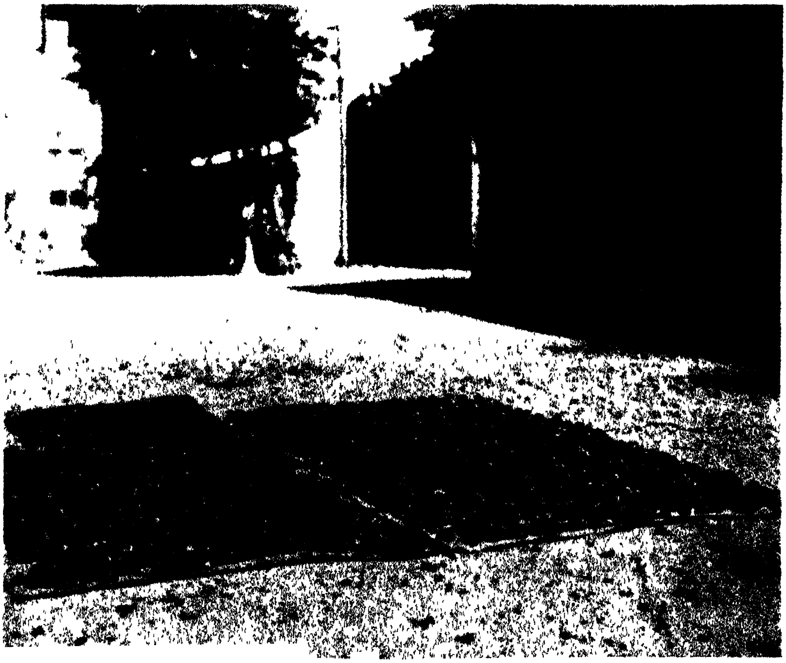


Fig. 2.— Ripe fruit from bunch shown in illustration above (on mat to the right).

and therefore tough; a yellowish oily mesocarp (pulp), varying in thickness from 2 to 6 millimetres, and containing more or less fibre in longitudinal strands; and an ovoid or sub-spherical endocarp or nut-shell, usually 15 to 25 mm. long, and 12 to 16 mm. across, but sometimes as much as 30 mm. in length and at others not larger than a pea. The endocarp is ridged with adherent fibres externally, and has 3 (or sometimes 1, 2, 4 or 5) "pores" or "eyes" at its apex, through one of which the sprouting embryo finds an exit. The shell is extremely dense and varies in thickness in different varieties from 0·5 to 4·5 mm., so as generally to require the use of a hammer to break it. Though usually one-seeded, 5 to 10 per cent. of the fruits are said to have two, and 1 or 2 per cent. three seeds or kernels.

Seed

The seed or kernel nearly fills the interior of the nut or endocarp, adhering to the inner surface of the shell except at the apex, but separating, as can be detected by its rattling in the nut, after a few weeks' exposure to the sun. It is usually 12 to 22 mm. long, and 8 to 12 mm. in diameter and solid, but, as it contracts in drying, a cavity forms at the centre. The very thin and closely adherent outer skin (testa) from yellowish or flesh-coloured turns blackish with a network of whitish veins; the bluish-white translucent endosperm is cartilaginous, and is the source of the kernel oil; the embryo is small and straight and is situated at the upper end of the seed.

Chief Varieties of the Oil Palm

A large number of varieties of *Elaeis guineensis* occur in Africa, which are known to the natives in the different regions under various local names. The most complete description of the known varieties, from a botanical point of view, is that given by Professor O. Beccari (*L'Agricoltura Coloniale*, 1914, 7, 5, 108, 201, 255) who distinguishes no less than eighteen different varieties and forms. It is not necessary here to deal with the botanical characters of these varieties, some of which are only of infrequent occurrence, and of little or no commercial

importance; for such details reference must be made to the original paper, which should be read in conjunction with an article in the *Kew Bulletin* (1914, p. 285) in which the different native names are correlated with the botanical varieties established by Beccari.

From a commercial point of view the varieties fall into two main groups: (1) those whose fruits have a comparatively thin pulp and thick shell, and contain a comparatively small amount of palm oil, but usually a large percentage of kernels; and (2) those with a thick, fleshy pulp and thin shell, containing a large amount of palm oil, and often a comparatively small percentage of kernels. The greater number of palms in West Africa are of varieties which fall in the first group, and it is from these that the bulk of the commercial supplies of palm oil and kernels is obtained. A list of the chief forms found in West Africa arranged under the varieties recognised by Beccari, together with the character of the shell, average weight of the fruit and the percentage of palm oil and kernel in the fruit, are given in the following table.

Characters of Fruits of Chief Varieties of Oil Palm

Variety.	Character of shell.	Weight of fruit.	Oil.	Kernels.
var. *communis*:		*Grams.*	*Per cent.*	*Per cent.*
Ope-pankora (Nigeria) . . .	thick	7·4	19	19
Udin (Nigeria)	"	7·1	16	13
var. *communis* forma *dura*:				
Abe-pa (Gold Coast)	"	9·6	19	22
Ak-po-ro-jub (Nigeria)	"	12·8	26	11
Dé (Togo)	"	4·17	16	21
var. *communis* forma *fatua*:				
Abe-oam (Gold Coast)	"	7·0	23	15
var. *communis* forma *semi-dura*:				
Abe-tuntum (Gold Coast) . . .	"	7·4	17	18
var. *macrophylla*:				
Abubu-be (Gold Coast) . . .	medium thickness	5·9	3·1	21
var. *Ceredia*:				
Adi-be (Gold Coast) . . .	thin	6·7	45	12·5
Abedam-adibe (Gold Coast) . .	"	3·95	41·7	—
var. *communis* forma *tenera*:				
Abobo-be (Gold Coast)	"	5·1	44	20
A-sog-e-jub (Nigeria)	"	12·6	48	9
Lisombé (Cameroons) (1) . . .	"	7·4	44	17·3
" " (2) . . .	"	10·0	39	12·5
var. *idolatrica* (King or fetish palm):				
Ogiedi (Nigeria)	"	4·3	35	8
Af-fia-ko-jub (Nigeria)	"	12·6	38	11·5
var. (?):				
Ayara mbana (Nigeria) . . .	thick	8·9	42[1]	12·9

[1] 14·8 *per cent. in the fleshy perianth and* 27·2 *per cent. in the pulp.*

For further details as to the character of the fruits of the different varieties, reference should be made to the article on "The African Palm Oil Industry" in this BULLETIN (1909, **7**, 357). The form known to the Eifik people of Calabar, Nigeria, as "Ayara mbana" is peculiar in that the perianth, instead of being membranous as in other varieties, becomes fleshy and contains a large amount of oil.

In some forms, *e.g.* the "Votchi" of Dahomey and "Difumbé" of Angola, the shell is reduced to a mere felt of fibres or a translucent yellow horny membrane, whilst the kernel is small or absent.

The different varieties are considered from the point of view of cultivation in the section on "Selection of Seed" (p. 229).

CULTIVATION

Elevation and Climatic Conditions

Although tolerant of brackish water, and sometimes even competing with the coconut for the beach, oil palms should be at least three feet above sea-level. They occur at altitudes of over 3,000 ft. in the French Sudan, but become few in number at half that height in the cloudy mountains of San Thomé and Fonta-Djalon. It is stated in *Ergänzungsheft No.* 13 *der Mitteilungen aus den Deutschen Schutzgebieten*, Berlin, 1917 (abstract in *Kew Bulletin*, 1918, p. 197), that oil palms give good yields at elevations up to 2,300 ft. in the Cameroons, and occur in a wild state there at 4,000 ft., and occasionally at 4,700 ft. Rutgers states that trees planted at a height of 975 ft. in Sumatra are not less productive than those grown at low elevations, and that there seems no reason to doubt that the limits of elevation in Africa would apply to Sumatra; it is probable that this statement is equally true in respect of Malaya.

The oil palm requires a mean annual temperature between 22° and 30° C. (71° and 86° F.), the thermometer rarely rising above 35° C. (95° F.) or falling below 15° C. (59° F.), the optimum mean being apparently about 25° C. (77° F.), which is also that for cocoa. The best

rainfall would seem to be from 70 to 100 in. a year, though the palms can grow with a rainfall of less than 40 and more than 250 in. On the southern frontier of Wadai, where there is a dry season of six months' duration and less than 39 in. annual rainfall, the palms grow only in well irrigated valleys. The best conditions, however, are not those of the highest rainfall, but where the rain is spread over many months, with frequent short small falls, alternating with days of sunshine. The palms make most of their growth during the heavy rains and form most of their flower-heads in the height of the wet season. The yield of oil is increased for two years after a year of high rainfall, and the fruiting spadices, or "cones," grow larger and yield more oil when the "short rains" are heaviest. In Cochin-China it has been found that with a distinctly tropical climate of two contrasting seasons the introduced palms make slower growth than in the equatorial climate of Malaya. On the West African coast a long, dry harmattan, or north-east wind, is distinctly detrimental, though there is generally some morning dew. These trees, in fact, rejoice in a constantly saturated atmosphere.

Oil palms are essentially light-demanding species. In dense jungle they are represented merely by bird-sown stragglers, generally choked and stunted by competing vegetation or drawn up with tall, slender stems and often nearly or completely sterile. They flourish and multiply greatly by self-sown seedlings in clearings or on the flanks of the forest, in the gallery forests along the river bottoms, by lagoons and on land that has been under cultivation. The black colour of the unripe fruit appears to be a special adaptation for the absorption of heat-rays, and sunshine is essential for the ripening, if not also for the full development, of the fruit.

Soil Conditions

The most favourable conditions for the cultivation of the oil palm, realised in the Niger delta, the Ivory Coast, San Thomé and on the Lower Congo, would seem to be repeated in the Seychelles and in Eastern Sumatra,

on low-lying parts of the Federated Malay States, Java, Borneo, British Guiana and Brazil, and, perhaps, also in parts of the Philippines.

The character of the sub-soil is not very material, provided that the surface soil is deep and fairly wel drained. Wild palms are scantier on granitic and gneissic sub-soils in the interior of Dahomey, but do well even on such rocky land if weathering has produced a good depth of soil. The natives recognise that the palms do better on alluvial river-bottoms, or on the ferruginous lateritic clay (the Portuguese *terra barro*) which covers most of Lower Dahomey to a considerable depth, than on loose sand. No oil-palm does well on sand-dunes; but the King or fetish palm (*Elaeis Djbowskii*, Hua = *E. guineensis* var. *idolatrica*, Chev.) flourishes just behind the dunes of Lagos, where a little humus has accumulated, but where the ordinary forms make very poor growth. The trees bear earlier on alluvium, give the largest fruit clusters and the most pulp, the yield being proportional to the humidity of the soil. The palms do well in lands inundated at least once during the year, though it is not necessary that the ground should be saturated for more than two or three months. The productive soils are often poor in lime and not very rich in potash or phosphates, but are usually highly nitrogenous, former forest land, rich in humus, being the best. So much of this land has at one time or another been under the extravagant native "chena" cultivation of the former large population of slaves in transit from the interior to the coast as to make some observers believe the oil palm to be not truly wild. Oil palms have a deep and wide root-system, and, therefore, require the soil to be light enough for their roots to penetrate it readily, while one of the chief uses of the humus, which is so essential, is the retention of moisture in the soil.

Chevalier and Hubert have both come to the conclusion that the oil palm gives the best yields on rich, alluvial, not too heavy soils, but will also flourish on other soils provided that they are not marshy. The experience that has been gained up to the present on the east coast

of Sumatra, according to Rutgers, confirms this opinion. Well-developed and heavily bearing trees are found on all kinds of soil, including the Tertiary upland soils of Tamiang which consist largely of deep clay, the much younger and looser tufa soils of Siantar, and the sandy banks of the Asahan River in Upper Asahan. The adaptability of the oil palm is also demonstrated by the fact that the tree can be grown with success as an ornamental plant in all sorts of circumstances, and even under the unfavourable conditions of city gardens.

Apparently contradictory statements as to the suitability of swampy or marshy ground are explicable by the necessity that the soil, though moist, shall be neutral or alkaline, which practically implies that the water shall not be stagnant at the roots of the trees.

Weeds and Clearing

It is abundantly clear that oil palms suffer considerably both in vegetative growth and in productivity from surrounding vegetation, competing for soil-water and for light, that is both under and above ground. The Woburn fruit experiments seem to show that grasses may have a specially toxic action on the soil; and in order to eradicate such strong-growing weeds as the sonnia (*Imperata cylindrica*), a West African ally of the too well-known lalang-grass of the Far East, and the nut-grass (*Cyperus esculentus*), it is not sufficient to cut or burn the parts above-ground, but the subterranean rhizomes or corms must be completely hoed up and burnt. The native methods of clearing land for cultivation in West Africa consist mainly in cutting and burning the brushwood, and in ringing and felling the larger trees which are not to be retained as useful, leaving the stumps as a breeding-ground for destructive fungi and termites. A far better, though somewhat laborious, method is to dig round and cut the main roots until the trees fall and tear themselves out of the ground. Brushwood, roots and weeds should be piled together, and thus burnt under control at one time, preferably during the dry season.

Propagation

Seed is the only means by which oil palms can be propagated. There are no offsets, although seedlings close to the base of the stem have been mistaken for such structures ; nor is there any possibility of grafting. Seeds are dispersed by birds, apes and squirrels which eat the oily outer pulp and reject the stone or nut, whilst the pulp of those fruits which fall to the ground is destroyed by insects or atmospheric action. The seeds of many such fruits rot, those only sprouting which are slightly buried or at least shaded. Germination takes place in four or five weeks—seeds, that is to say, falling in the dry season sprout during the succeeding rains ; but, unlike most oily seeds, palm-nuts—perhaps only when the endocarp does not perish—appear to retain their vitality for a long period, some of them germinating a year after falling. To secure regular germination it is recommended that fruits should be fermented for some days in a sack or box before sowing (*Der Pflanzer*, 1913, **9**, 141). If seed is to be transported to a distance it will probably be best to depulp the fruits without the use of heat, dry the nuts and pack them in charcoal.

Selection of Seed

In most cases where plantations have been made in West Africa, self-sown seedlings have been transplanted into prepared ground. By this method the only selection practised is, as pointed out by Farquhar (*The Oil Palm*, p. 14), that of the poorest varieties, the fruit-cones of which are left uncut on account of their known small yield and thus sow themselves, whilst the better sorts are harvested. In making a new plantation it is preferable to sow seed in specially prepared seed-beds and transplant the seedlings to their permanent quarters, this method of course being the only one possible in countries where the oil palm is being newly introduced.

Great care must be taken in the selection of seed for sowing. Not only do the numerous varieties of oil palm differ in the yield of fruit and percentage of oil and kernel, but there is a very great difference between the yielding

capacities of individual trees of the same variety. This is clearly shown by the results of determinations made on groups of trees in Sumatra and recorded by Rutgers.[-] In each series of test trees there were one or more trees which produced nothing whilst others gave yields which were far above the average.

The maximum yields per year which were observed for individual trees in the groups of trees described on pp. 242–244, were as follows:

St. Cyr, trees A .	34 years,	6 bunches,	148 kilograms
" " " B	20 "	6 "	198 "
" " " E	15 "	14 "	270 "
" " " H	7 "	3 "	25 "
Mata Pao .	5 "	36 "	93 "
" " .	5 "	17 "	72 "
Bekalla, trees B	30 "	10 "	172 "
" " B	30 "	8 "	168 "
" " A	20 "	14 "	280 "
" " A	20 "	20 "	264 "
Poeloe Radja	7 "	20 "	265 "

The heaviest bunch was obtained from St. Cyr, and weighed about 57 kilograms.

In contrast with these heavily yielding trees there are others in each group giving little or no production, and it is therefore evident that it is desirable that palms giving an abundant crop should be chosen for seed trees. It is probable that plantations made from the seed of such trees will give improved yields.

In order to determine as quickly as possible whether any considerable increase in production can be obtained in this way, it is desirable that daughter trees should be planted from numbered mother trees of high and of low productivity. If after some years it is actually found, as may be anticipated, that the oil palms in daughter plantations raised from mother trees of high productivity give greatly improved yields, it will be possible to increase the production considerably in the future by continuous selection according to this method.

The most desirable variety for cultivation will be one that comes into and remains in bearing when low enough to be easily harvested, will ripen its cones simultaneously, and yield large fruits with thick pulp rich in oil, thin shell and heavy kernel. Such a variety, as Chevalier points

out, probably does not exist, but could in time be obtained by breeding.

Unfortunately very little is known as to the yield of fruit in the different varieties of the oil palm, and it is not easy therefore to recommend definitely any particular variety for cultivation. Assuming that the yield is satisfactory, however, it is evident that a thin-shelled variety, such as the "Abobo-be" of the Gold Coast and "Lisombé" of the Cameroons, which gives a high yield of oil from the pulp, and a fair yield of kernels (cf. table on p. 224), should be selected. If the nuts are to be shelled by hand the thickness of the shell is a matter of great importance, but is of less consequence if nut-cracking machinery is employed.

Experience has hitherto shown that it takes several generations to obtain a race of thin-shelled palms true to type. In experiments with the "Lisombé" variety in the Cameroons only a small proportion of the seedlings came true to type in the first generation, whilst in the Gold Coast it was found that the "Abobo-be" variety gave both hard- and soft-shelled nuts in the same bunch. Careful selection experiments extended over at least fifteen years would probably be necessary before a pure race could be obtained. Whether such an elaborate procedure is necessary seems doubtful in view of the results obtained in Sumatra.

Seed-Beds

So far, the only experience in regard to sowing seeds in nurseries on a large scale has been gained in Sumatra, where, according to Rutgers, there is little uniformity at present in the manner of preparing the seed-beds. Different practices are adopted by the various undertakings, but without any appreciable difference in the results obtained. In some cases, the seed-beds are prepared with great care, whilst in others the seed is apparently merely pushed into the soil, but the germination always proceeds equally slowly. In the Botanical Garden, Buitenzorg, the soil of the seed-bed is worked to a depth of 1½ to 2 ft., and mixed with a little stable manure or leaf mould. The beds are 4 ft. wide, and are separated by a trench, 1 ft.

wide and 6 in. deep. The seeds are planted at a distance of 8 in. in each direction (Adam advises 20 in.), and are sown with the flat side downwards.

As a rule, the seed-beds are not raised, and this seems to be the better plan, as otherwise measures must be taken to prevent the washing out of the beds. When the beds are on the same level as the intervening paths, this is of course unnecessary.

As already mentioned, self-sown seeds in West Africa germinate in from four to five weeks, but in Sumatra it has been found that the seeds take a long time to germinate, generally about six to nine months. When fresh seeds are sown, some seedlings appear after from one to three months; but old seeds, such as those imported from Africa, sometimes take more than a year to germinate. Van Helten recommends that seeds which have not germinated within one and a half years should be thrown away, as such seeds never produce strong plants.

Rutgers, in the second of his papers already referred to, gives the results of experiments designed to ascertain the conditions which hasten germination. It was found that seeds treated with warm water or exposed to heat sprouted more quickly than seeds not so treated, and that a temperature up to 122° F., or even a little higher, causes no harm. On account of warmth being essential for quick germination, the shading of the seed-beds with a light thatch of "atap" (palm leaves), which is sometimes recommended, seems undesirable until the seedlings have appeared above ground.

Transplanting

In making plantations in West Africa seedlings are transplanted from the natural groves when 1 to 3 years old, or 1 to 3 ft. in total height, and transferred at the beginning of the rains to trenches. The latter, in compact soils, should be at least from 12 to 16 in. in width and depth, and 16 to 26 ft. apart, according to the fertility of the soil. The older leaves are removed from the seedling, leaving only 12 to 15 on the plant. Mr. R. Swainson-Hall, of Cabinda, Portuguese Congo, in an unpublished paper on the oil palm, kindly furnished to

the Imperial Institute by the author, recommends the selection of sturdy seedlings of much smaller size than those usually transplanted, viz. not more than 6 or 7 in. high. Larger plants must inevitably suffer damage to their extensive root-system. He further recommends planting the seedlings in holes, 20 to 30 in. in width and depth, prepared some time in advance so as to be acted upon by the weather. Whether holes or trenches are adopted, they should be half filled with dead leaves or other humus and stable manure, if available, before planting.

In Sumatra, according to Rutgers, the plants are sometimes set out in the plantation when they have six or seven leaves, that is, when they are about a year old (Plate V, fig. 1). Even at a later age the palms can be satisfactorily transplanted, and there is no difficulty in setting out plants of two years in the plantation. In this case, however, the distance between the plants in the seed-bed must be considerably greater. The young plants can also withstand a long transport without suffering any damage.

The natives in West Africa often leave the wild trees within one or two yards of one another, especially where they are chiefly used for tapping for wine. This affords an insufficient circulation of air or access of light for good fruit-production, and it is now generally recognised in West Africa that a distance of 26 ft. between the trees (about 64 per acre) is best, where there is no inter-planting. In richer soil the palms may be placed farther apart. Planting should be carried out immediately after rain, to avoid the necessity of watering; and in dry weather each young plant should be shaded with three palm leaves placed in a triangle round it and tied together at the top, as is done in planting date palms in North Africa. Chevalier remarks that the natives will object to such laborious methods, but will be unable to ignore the advantages gained.

In Sumatra most oil palms are planted 10 × 10 metres (33 × 33 ft.) or 9 × 9 metres (29½ × 29½ ft.). Rutgers is strongly of opinion that the former spacing is too wide, and that even a distance of 9 × 9 metres is too great. He

therefore advises 8 × 8 metres (26 × 26 ft.), the same spacing that is considered best in West Africa.

Pruning

Before cutting the fruit-cone the West African native has generally to cut away five or six leaves to get at it. These will frequently be still green, and, to save trouble, they are often cut at some little distance above their base. In those parts of the western regions of the Southern Provinces of Nigeria where the oil palms are most carefully treated, some leaves are removed every year at the harvest period from palms of more than seven years old, and this is stated to increase the yield of fruit by 25 to 50 per cent. In San Thomé these leaves are removed soon after the flower-heads have formed, and, being cut low down, no longer exert pressure upon the enlarging fruits. Their removal also stimulates the production of fresh and more actively assimilating leaves. It is considered in West Africa that six or eight leaves, at least as many as are annually produced, may advantageously be removed each year, so that only 15 to 25 are allowed to remain.

Fauconnier records that young palms planted in a rubber-plantation at Xacam, Indo-China, in 1914, were quite barren in 1917; all the lower leaves were then stripped off, whereupon the trees put out numerous female cones within a few weeks, whilst other plants not so treated remained barren a year later (*Bull. Econ. de l'Indo-Chine*, 1918, **21**, 302). By cutting the leaves when the fruit begins to ripen it is now believed that 50 per cent. is added to the yield, trees from five to seven years old bearing 12 cones a year with an average of over 20 lb. of fruit each (*Bull. Mat. grasses, Marseille*, No. 6, 1919, p. 226).

On the east coast of Sumatra it is usual to remove the lowest leaves from trees which are in bearing (Plate III, fig. 1). Accordingly all the leaves in the axils of which fruit has set are cut off close to the stem so that the bunch of fruit, which otherwise would be pressed between the leaf-stalks (Plate III, fig. 2), has an opportunity to expand. It appears certain that this practice results

Fig. 1.—Oil palms, Sumatra, showing method of removing leaves to allow fruit heads to expand.

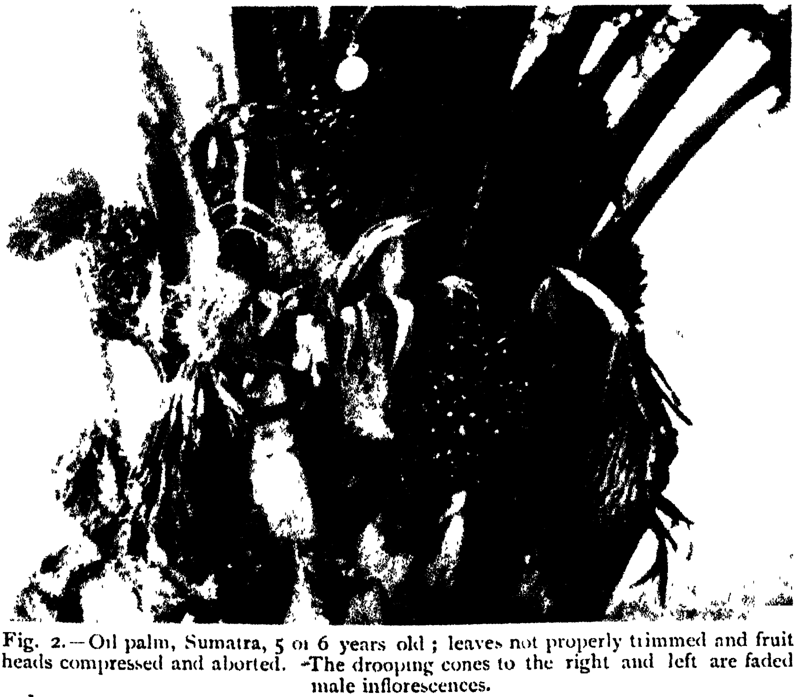


Fig. 2.—Oil palm, Sumatra, 5 or 6 years old; leaves not properly trimmed and fruit heads compressed and aborted. The drooping cones to the right and left are faded male inflorescences.

in the production of heavier bunches. On the other hand, Rutgers has formed the opinion from his own observations that the new cones of a tree from which more than half the leaves have been removed are much reduced in size. Definite trials are needed, however, in order to determine this point with certainty. In the light of present knowledge, it seems best to recommend a moderate pruning in which the only leaves removed are those from which the bunch is harvested.

Manuring

Although no special manuring of the oil palm is usually practised in West Africa, it seems likely that this will be necessary under plantation conditions where the improved care of the trees results in larger yields and consequently greater depletion of the food materials in the soil. Analyses of the entire palm made by Zeller (*Der Tropenpflanzer*, 1911, **15**, 355) show that the ash is rich in potash and phosphoric acid. He estimates that the amounts of these constituents removed each year by the crop of a single tree are, potash 102 grams, and phosphoric acid 53 grams; the amount of nitrogen removed is given as 128 grams. In addition to the crop, however, under proper cultivation several leaves will be cut off each year, resulting in a further loss of food constituents. The leaves so removed and all other vegetable refuse should be burnt, and the ashes applied to the soil, thus replacing some at least of the potash and phosphoric acid. Stable manure, if available, should be forked in between the trees. Nitrogen can be added to the soil by ploughing in a green manure crop, *e.g.* species of *Crotalaria*; this will also improve the soil by the provision of humus.

Catch-crops and Inter-crops

During the first few years after planting there will be a considerable area of land between the oil palms, available for growing other crops. The advantage of growing catch-crops, apart from the revenue they bring in, is that the soil is improved by the cultivation that the secondary crop requires, whilst weeds are kept down.

Suitable crops for this purpose are maize (whilst the palms are still small), haricots, pigeon peas and pine-apples. It would probably not pay to grow ground nuts, except as a green manure, as they do not do well under the shade of the palms, whilst exhausting crops, like cassava and yams, should be avoided, unless plenty of manure is available.

It has been suggested that cocoa would do well planted between the rows of oil palms, as the close mat of roots formed by the latter conserve moisture, and would furnish an almost inexhaustible supply of water to the roots of the cocoa, whilst the shade provided by the palms would also be beneficial. If cocoa is grown in this way, the rows of palms should be farther apart than in pure plantations, and it will be necessary to add more manure to the land.

Para rubber has been interplanted with the oil palm on some plantations in the East, but the results have not been altogether satisfactory.

Diseases and Pests

The oil palm has hitherto been remarkably free from serious diseases and pests, both in its wild habitat and in plantations. With the extended cultivation of the tree, however, there is the possibility of serious damage caused by both fungi and insects, just as happened in the case of Para rubber, coffee and other crops, when these were transferred from their native forests to plantations, where the natural enemies of the insect pests are absent or less abundant, and where the conditions are more favourable to the spread of fungoid diseases. It is important, therefore, that at the first appearance of disease or pests every possible precaution be taken to prevent them from spreading.

Fungoid Diseases.—In the case of fungoid disease it is a safe plan to remove and burn all affected leaves, and, if the tree shows signs of dying, to uproot and destroy it. It is not sufficient merely to cut down the tree, as the fungus causing the disease may occur in the roots, and spread through the ground to other trees. If a disease affecting the leaves or the central bud ("cabbage")

shows signs of spreading, the trees should be sprayed with Bordeaux mixture or other suitable fungicide, and in the case of a root disease the infected area should be isolated by a trench 2 ft. deep and the soil in the neighbourhood treated with freshly slaked lime.

According to information supplied to the Imperial Institute, a root disease of the oil palm caused by a fungus which appears to be *Ganoderma tumidum*, a close relative of *Fomes semitostus* (the root disease of Para rubber), is common and widely distributed in the Belgian Congo. It generally attacks mature trees, but young palms are sometimes killed (this BULLETIN, 1915, **13**, 479).

A similar disease, caused by *Ganoderma applanatum*, is very prevalent in San Thomé (*L'Agronomie Coloniale*, 1920, **4**, 187). The fungus attacks the base of the trunk both above and below the surface of the ground, eventually forming a large cavity, which weakens the stem, so that the tree falls to the ground. The disease is not easily discernible in its early stages, which may extend over several years, as the tree continues to produce fruits, and the leaves appear to be completely healthy. Before the cavity in the stem develops, however, the bracket-shaped fructifications of the fungus make their appearance on the diseased part of the stem ; as soon as these are seen the tree should be dug up and burnt, to prevent the spores infecting other palms. The infected area of land should be isolated by a trench, and the ground treated with lime as recommended above for root diseases in general.

In Sumatra, according to Rutgers, the leaves of young palms sometimes become bent over at about half their height, through the leaf becoming weak and sometimes rotten at this point, the upper half of the leaf subsequently falling off. No disease-producing organism has hitherto been found in connection with this condition, and it is very exceptional for the disease to cause the death of the plant.

Insect Pests.—By analogy with the coconut and other palms it seems most likely that the insects which will prove of the greatest danger to the oil palm will be boring beetles, caterpillars and scale insects. The methods commonly adopted to combat the first-named are (1) the

removal of the grub or beetle from its galleries by means of a piece of stiff iron wire and (2) the payment of a premium to natives for the capture of larvæ and adult insects. Certain beetles which attack palms deposit their eggs in the rotting humus which accumulates at the base of the leaves, or in decaying stems or logs. The periodical cleaning of the stems of the oil palm, and the destruction by burning of all fallen and decaying stems, which should be done on all plantations, will go far to keep such pests under control. Caterpillars, as a rule, have to be removed by hand and destroyed, but if present in large numbers the palms should be sprayed with a stomach poison, such as Paris green or other arsenical preparation. Leaves attacked by scale insects should be sprayed with a kerosene emulsion, rosin wash or similar contact poison, but badly infested leaves should be removed and burnt. Insectivorous birds should be encouraged as much as possible in the plantation, as they destroy large numbers of harmful insects.

In West Africa very few insects have been recorded as damaging the oil palm. W. A. Lamborn, in his paper on *Agricultural Pests of Southern Provinces, Nigeria* (*Bulletin Agric. Res.*, 1915, **5**, 214) states that the only insect he found attacking the oil palm in that country was the grain weevil (*Calandra oryzae*), which had bored into an oil palm scorched by repeated bush fires. In Dahomey he found weevils belonging to four species of *Derclomus* feeding on the fresh male flowers, the most abundant being *D. kamerunicus*. R. Mayné (*Bulletin Agric. Congo Belge*, 1915, **6**, 266) also records a beetle in the Belgian Congo (hitherto not identified) the young larvæ of which attack the flowers of the oil palm. The older larvæ and the adult beetle bore into the green stumps of recently cut leaves, and into the leaf-stalks. The chief damage is caused by the young larvæ, however, the destruction of the male and female flowers resulting in diminution in the yield of fruits. The methods of control recommended are the removal and burning of leaf-stumps and attacked leaves, and also of badly infested inflorescences.

Mayné also describes three other beetles which attack the oil palm in the Belgian Congo: two species of

Oryctes, viz. *O. monoceros* and *O. boas*, and *Rhyncophorus phœnicis*, the red palm weevil. The last-named is the most serious pest in the Belgian Congo, and it has also been found attacking the oil palm in the Gold Coast. These beetles attack the coconut palm and Borassus as well as the oil palm.

In the *Oryctes*, which are closely related to the rhinoceros beetle, the most serious enemy of the coconut palm, the damage is caused by the adult beetles. These generally enter the petiole of a leaf, and bore towards the centre of the trunk, sometimes destroying the terminal bud and killing the tree. The death of the tree may also be brought about through the introduction of secondary parasites into the tunnels of the beetle. These beetles should be combated by the methods described on p. 238, and, as the eggs are deposited and the larvæ live in moist decaying vegetation, particular attention should be paid to the destruction of all such material. Trees which are badly attacked should be burnt or submersed in water. In Dahomey also the oil palm is attacked by a species of *Oryctes*, but this does not appear to cause much damage.

In the case of the red palm weevil the damage is caused by the larvæ. The eggs are laid often comparatively deep down in the tissues of the stem, in galleries made by the Oryctes beetles or in wounds and cracks on the stem or leaf-stalk. The larva bores up towards the terminal bud, which is sometimes destroyed, resulting in the death of the tree. From its position in the "cabbage" of the palm, this pest is difficult to destroy, and preventive methods are essential. Boring beetles such as Oryctes should be kept down, and, if the weevil is prevalent in the district, wounds in the stem should be painted with tar, to prevent the beetle from depositing its eggs in the tissues of the palm. Badly attacked trees should be cut down and destroyed.

A small Hispid beetle (*Promecotheca* sp.) sometimes causes severe damage to oil palms in the Gold Coast. The larvæ feed on the tissues between the upper and lower surfaces of the leaf, causing large brown blotches of dead material to form. Affected leaflets should be cut off and

burnt, and if the attack is severe the whole leaf should be removed and destroyed.

Caterpillars have not proved serious pests of the oil palm so far. Two kinds have been observed in Sumatra, which belong respectively to the *Psychidae* and the *Limacoididae*. The latter not only cause damage to the trees, but are objectionable to the workers on account of injurious hairs which they bear and which occasion a painful irritation. The only method of controlling these insects is to catch them. Nature affords considerable assistance, however, in reducing the numbers, for as soon as the caterpillars become numerous they are decimated by parasitic fungi and ichneumon flies.

In Dahomey the scale, *Aspidiotus destructor*, which is sometimes a serious pest of the coconut palm, has been recorded as attacking the oil palm, but without causing much damage.

Harvesting

As already mentioned, the fruits of the oil palm ripen over a period of from two to six months, although those on any one bunch usually ripen together. To save themselves the trouble of several climbs, the West African negroes will sometimes cut five cones from one tree, choosing a time when they have no other agricultural work in hand, though they do not generally begin their harvest until some over-ripe fruits begin to fall. In this way cones are harvested when over-ripe and when unripe.

Harvesting the fruits from wild trees presents some difficulty, as often several leaves have to be cut away before the fruit-bunch can be reached. On a well-managed plantation, where the lower leaves are regularly removed to allow the fruits to expand fully, the difficulty is reduced. Old tall trees have to be climbed before the bunches can be cut (Plate IV), and Matthieu (*Gardens' Bulletin, Straits Settlements*, 1920, **2**, 217) has expressed a doubt as to whether harvesting the hard-stalked prickly oil palm will commend itself to the Malay labourer who has been accustomed to the more tractable coconut. It will probably prove necessary in the East to use ladders for gathering the bunches, and to discard trees which are

PLATE IV

Collecting the "heads" of palm fruits in Sierra Leone.

PLATE X

Fig. 1. Young oil palms, Sumatra. On left 1 year old, on right 2 years old.

Fig. 2. - Oil palms, Sumatra, 5 years from planting.

too tall to be reached by this means. Even in parts of West Africa, it is stated, it is becoming difficult to obtain sufficient climbers to harvest the fruits from tall trees.

Great care must be taken in gathering the bunches. If the fruits become damaged fermentation sets in, and the palm oil obtained will be of high acidity and inferior quality.

Yield

The yield of fruits from wild oil palms varies greatly, depending not only on the variety of palm, but on the spacing, the care that has been devoted to the trees and other considerations. Figures derived from such sources, therefore, afford no criterion as to the yield that may be expected from carefully tended plantations. Rutgers, however, has published full estimates of the yield obtained from trees in Sumatra, and the following particulars are taken from his papers.

The data employed for calculating the figures given in the following pages were collected on different undertakings with trees of various ages. Among these were trees in regular plantations and also trees in avenues on tobacco plantations (Plates V, VI). The latter were taken into observation because the oldest regular plantings were hardly seven years old, whilst, in the avenues, trees of from 7 to 34 years old were available.

As far as can be traced, all the trees from which the data used for the calculations were obtained are derived from a single variety. From the figures given in the tables on pages 247 and 249, it would appear that this is not the same variety as that grown at Buitenzorg, Java. It is quite possible, however, that the percentages of pulp and kernels may vary for the same variety when grown under different conditions of soil and climate.

By far the great majority of the oil palms on the east coast of Sumatra are derived from seed of the old trees in the avenues at St. Cyr, which were grown from seed imported about 1884 from the Botanical Garden at Singapore. Moreover, the avenue trees on the plantations at Bekalla (1888) and Tandjong Morawa (1903) which have yielded much of the seed used for later plantings show

no difference from the trees at St. Cyr, and all these trees must therefore be provisionally regarded as of one variety. It is not yet decided with which African variety this kind is identical.

In recent years a number of other varieties have been imported into the east coast of Sumatra, in part direct from Africa, and in part as seed from imported trees growing on the selection station at Buitenzorg. Most of the plants thus raised have not yet borne fruit. At Mendaris and Soengei Brohol, however, are some hundreds of trees in bearing which are all derived from a variety imported from Togo. The percentage of pulp and kernels in this case is so small (see footnote on page 247) that this variety will certainly not be further planted.

The determinations of yield and the estimations of oil-content which are recorded in Rutgers's papers relate to the groups of trees described below. In each of these groups ten to twenty numbered trees were taken into observation. Once or twice a month the officers of the Experiment Station collected and weighed the ripe fruits from each tree. The whole of the product was thus removed, bunch by bunch, and the weight of the stalks, fruits, pulp, nuts and kernels determined. In the case of some groups these observations were made for a whole year, and in others for single months.

The following remarks apply to the different groups of trees on which the observations were made.

A. Avenue Trees.

1. *Tobacco Plantation at St. Cyr.*—Height above sea-level: 86 metres (282 ft.). On this estate are some very fine avenues of oil palms containing the oldest trees on the east coast of Sumatra. The oldest part of these avenues was planted in 1884, whilst further portions were planted subsequently at intervals of several years. For observation there were selected 10 trees A, 34 years old, 10 trees B, 20 years old, 10 trees E, 15 years old, and 10 trees H, 7 years old. Seed had been harvested from all these trees for several years, so that they were very well cleaned and free from superfluous leaves. The trees in the rows are, however, only 4·5 and 5 metres

Fig. 1.—Avenue of oil palms, Sumatra, 11-15 years old.

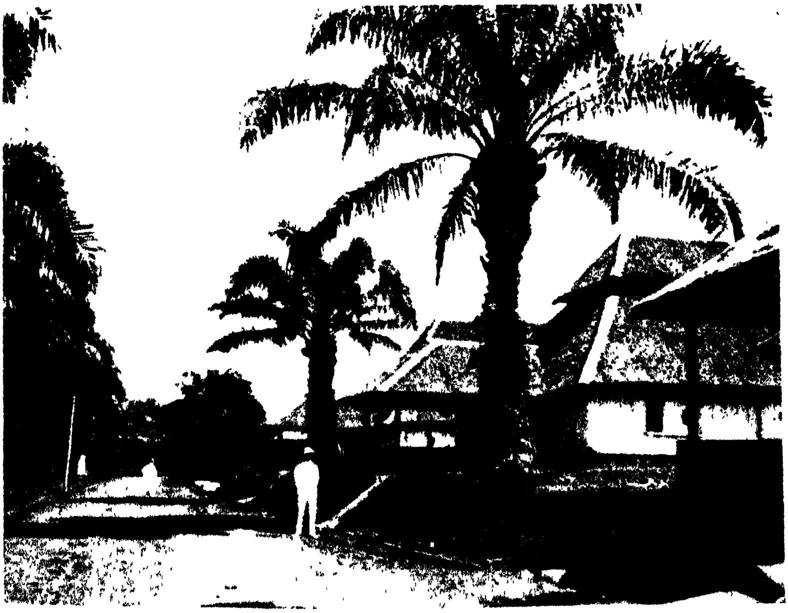


Fig. 2.—Old oil palms, Sumatra, used as seed trees.

apart, and, moreover, they stand, in part, half under troublesome Ficus, so that the conditions are very unfavourable for good yields of fruit. The observations were continued for twelve months.

2. *Tobacco Plantation at Bekalla.*—Height above sea-level: 62 metres (203 ft.). On this estate two groups of trees were taken into observation, one of which consists of avenue trees, whilst the other must be regarded as plantation (see 6 below). The avenue trees stand at a mutual distance of 10 metres (33 ft.) in a field of grass, but are otherwise quite free. They are thirty years old, and no attention has ever been given to their cultivation. The yield of ten of these trees was observed during six months.

3. *Coffee and Rubber Undertaking at Marihat.*—Height above sea-level: 360 metres (1,180 ft.). The 139 avenue trees on this estate, to which the figures on the following pages refer, are planted 8 metres (26 ft.) apart along a road which runs through a rubber plantation with coffee as an inter-culture. The whole plantation dates from 1914. The oil palms which are thus not yet fully five years old, have abundant light and air. The determinations of the yields of these trees were not carried out by the officers of the Experiment Station, but by the administration of the undertaking.

B. Plantation Trees.

4. *Oil Palm Estate at Mata Pao.*—Height above sea-level: 10 metres (33 ft.). The figures in the case of this undertaking refer to a row of twenty trees, five years of age, planted 10 × 10 metres, with coffee as an inter-culture. The trees have been regularly maintained, and the practice has been followed of cutting off the leaves as soon as the inflorescence in the axil has set fruit. The observations were carried out over twelve months.

5. *Oil Palm Estate at Poeloe Radja.*—Height above sea-level: about 50 metres (165 ft.). The figures in this instance relate to a row of twenty trees, seven years old, planted 9 × 9 metres (29½ × 29½ ft.), between which coffee was formerly grown. The trees have been regularly main-

tained, and, according to the custom of the undertaking, the leaves have been removed as soon as the inflorescence in the axil has set fruit. The observations were made over a period of six months.

6. *Tobacco Plantation at Bekalla.*—Height above sea-level: 62 metres (203 ft.). The fourteen trees to which the second group of figures for this plantation relates are regarded as plantation trees, as they stand quite free in a field of grass and grow under conditions which are not markedly inferior to those of a regular plantation. Their age is about twenty years. The observations were carried out for six months.

7. *Rubber Plantation at Piassa Oeloe.*—Height above sea-level: 90 metres (295 ft.). A trial plantation of 281 trees was established on this estate in 1912–13; the trees stand 12 × 12 metres (39 × 39 ft.) apart. The determinations of yield, which were made for a period of six months, were not carried out by the officers of the Experiment Station, but by the administration of the undertaking.

The starting-point for the calculation of the total yield of an oil palm plantation is the yield per tree per year. This quantity comprises (*a*) the gross yield of bunches and fruits, (*b*) the percentage of pulp, nuts and kernels in the fruits, and (*c*) the oil content of the pulp and kernels. The following pages summarise the results in tabular form.

The three items (*a*), (*b*) and (*c*) are treated separately, and in each case figures are recorded which were obtained (1) in the east coast of Sumatra, (2) at Buitenzorg, and (3) in Africa.

Before proceeding to the tables, three further remarks must be made.

1. The figures for Africa all relate to the wild palms, and it may therefore be foreseen that they are too low. This is true to a small extent of the neglected plantation at Buitenzorg and the avenue trees on the east coast of Sumatra.

2. The plantation at Buitenzorg and the oldest avenue trees on the east coast of Sumatra have already passed the limit of their maximum productivity.

3. The plantation trees on the east coast of Sumatra have diminished in productivity, probably owing to the heavy pruning to which they have been subjected.

(a) *The Gross Yield of Bunches and Fruits*

The table given below gives a comparative survey of the gross yield in bunches and fruits per tree per year for Sumatra, Buitenzorg and Africa.

TABLE I

Yield per tree per year in lb.

Locality.	Year of planting.	Year.	Number of bunches.	Weight per bunch.	Total weight of bunches.	Total weight of fruits.
East Coast of Sumatra:						
Mata Pao Plantation I	1913	1918	12·1	6·6	80	31
		1919	9·2	10·8	199	40
" " " II	"	1918	—	—	—	—
		1919	9·5	12·1	115	51[1]
Poeloe Radja Plantation I . . .	1912	1918	11·3	14·0	158	51
		1919	14·5	14·7	213	40[2]
Poeloe Radja Plantation II . . .	"	1918	—	—	—	—
		1919	12·6	16·5	208	53[1]
Bekalla Plantation .	1898	1918	11·0	34·0	374	145
		1919	9·5	35·6	341	123
Avenue trees, St. Cyr H	1911	1918	2·4	9·9	24	11
" " " E	1903	1918	6·8	40·9	278	136
" " " B	1898	1918	4·9	56·3	275	150
" " " A	1884	1918	2·5	47·7	119	66
" " Bekalla .	1888	1918	5·2	29·5	153	70
		1919	6·0	30·1	180	70
Buitenzorg, Java:						
Neglected plantation in Tjilendek Garden, 1916 and 1917 (Van Helten)	1876	1916 and 1917	2·3	41·8	96	48
Africa.						
Dahomey, Adam .	—	—	10	13·2	132	55
" Chevalier .	—	—	8	13·2	106	70
" Hubert .	—	—	7	13·2	92	62
Guinea, Adam . .	—	—	5	13·2	66	44
" Chevalier .	—	—	5	11	55	35
" Hubert . .	—	—	4	11	44	29
Ivory Coast, Chevalier	—	—	8	26·4	211	143
" Hubert .	—	—	7	11	27	51
Senegal, Hubert .	—	—	4	8·8	35	22
Average . . .	—	—	6·4	13·4	91	57

[1] *These trees were not so thoroughly pruned as those in Group* I.

[2] *The low yield of fruits in this group in* 1919 *was due to imperfect pollination.*

Before proceeding to draw any conclusions from these figures, Rutgers makes the following observations.

1. The avenue trees at Bekalla and the oldest at St. Cyr (A) have already evidently passed their maximum, and the same is true in even greater degree of the trees at Buitenzorg.

2. All the avenue trees at St. Cyr are in an unfavourable condition; they are only 4·5 metres to 5 metres apart (15 to 17 ft.) and are half under old Ficus. Their production is, therefore, always lower than that of comparable trees elsewhere.

3. The figures for the Bekalla plantation relate to fourteen trees which stand at great distances from one another in a field of grass. These trees are never tended.

4. On comparing the figures for Groups H, E and B at St. Cyr with one another, it is clear that, as the tree advances in age, the bunches become heavier; this is confirmed by the other figures.

5. The older trees give heavier bunches, but in smaller numbers. This has been already demonstrated by Soskin in the case of African palms.

The conclusions, based mainly on the plantations (printed in italics in the tables), lead to the following estimate of the normal yield of a plantation.

TABLE II

Estimated normal yield of a plantation per tree per year in lbs.

—	Number of bunches.	Weight per bunch.	Total weight of bunches.	Total weight of fruits.
5th to 10th year	12	13·2	158	53
11th to 30th year	10	33	330	165
31st to 50th year	3	44	132	66

(*b*) *The Percentage of Pulp, Nuts and Kernels in the Fruits*

The following table gives a comparative statement of the percentage of pulp, nuts and kernels in the fruits.

TABLE III

Weight of bunches, pulp, nuts and kernels, per cent. of the whole fruit

Locality.	Year of planting.	Year.	Bunches.	Fruits.	Pulp.	Nuts.	Kernels.
East Coast of Sumatra:							
Mata Pao Plantation I . .	1913	1918	270	100	60	40	7
		1919	250	100	56	44	9
Mata Pao Plantation II . .	,,	1918	—	—	—	—	—
		1919	240	100	61	39	8
Poeloe Radja Plantation I . .	1912	1918	310	100	63	37	7
		1919	450	100	—	—	—
Poeloe Radja Plantation II . .	,,	1918	—	—	—	—	—
		1919	390	100	—	—	—
Bekalla Plantation .	1898	1918	255	100	65	35	8
		1919	280	100	62	38	8
Avenue trees, St. Cyr H . .	1911	1918	200	100	64	36	8
Avenue trees, St. Cyr E . .	1903	1918	220	100	65	35	7
Avenue trees, St. Cyr B . .	1898	1918	200	100	55	45	11
Avenue trees, St. Cyr A . .	1884	1918	280	100	63	36	8
Avenue trees, Bekalla . .	1888	1918	215	100	62	38	9
		1919	210	100	55	45	12
Buitenzorg, Java:							
Neglected plantation in Tjilendek Garden 1916 and 1917 (Van Helten)	1876	1916 and 1917	200	100	54	46	16
Africa: .							
Chevalier . .	—	—	150	100	40	60	20
Adam . . .	—	—	125	100	43	57	20
Hubert . .	—	—	150	100	44	56	20
Janssens . .	—	—	150	100	38	62	11
Janssens . .	—	—	175	100	63	37	10
Average . .	—	—	150	100	45	55	16

These results show that the oil palms which are at present generally planted on the east coast of Sumatra [1] give a high yield of pulp (62 per cent.), and a low yield of kernels (8 per cent.). As a basis for the calculations made in the next section of this article (p. 248), these figures are taken as 60 per cent. and 8 per cent.

[1] On the undertakings at Mendaris and Soengei Brohol there are 100 oil palms of another variety, imported from Togo. The pulp amounts in this case to only 30-50 per cent. of the whole fruit, and the kernels to 10-15 per cent. This variety is probably much less profitable.

(c) *The Oil Content of the Pulp and Kernels*

The detailed figures obtained in 1918 relating to this part of the subject are given in a paper by F. C. Van Heurn (*Mededeelingen van het Algemeen Proefstation der A. V. R. O. S.*, *Algemeene Serie*, No. 6, 1919), and the results are summarised in the following table.

TABLE IV

Oil content of pulp and kernels per cent.

Locality.	Age of trees.	Palm oil, per cent. of fresh pulp.		Palm kernel oil, per cent. of kernels.	
			Average.		Average.
East Coast of Sumatra:	Years.				
Mata Pao Plantation	5	32–44	36	55	55
Poeloe Radja Plantation	7	49–51	50	54	54
Marihat avenue trees	5	56–70	63	39–64	52
St. Cyr avenue trees	7–34	35–73	55	48–60	54
Bekalla trees	20–30	53–66	59	43–59	51
Buitenzorg:					
Neglected plantation in Tjilendek Garden	40	31–75	57·5	27–47	40
1916 and 1917 (Van Helten)		23–66	53·4	36–59	40
Africa:					
Dahomey (Adam)	—	—	51	—	49
Guinea (Adam)	—	—	57	—	49
Average (Hubert)	—	—	55	—	50
Imperial Institute	—	50–77	58	43–50	47
Average	—	—	55	—	49

From the above data it will be seen that the oil palms which are at present generally planted on the east coast of Sumatra yield fruits which contain 55 per cent. of oil in the pulp and about 50 per cent. in the kernels, and are thus of good quality. The figures of 55 per cent. and 50 per cent. are used as a basis for the further calculations given in the following section.

PROBABLE RETURN FROM AN OIL PALM PLANTATION

As already mentioned, the only figures hitherto published showing the actual yields of fruits on a large scale are those given by Rutgers, and his figures will be taken as the basis for calculating the monetary returns of an oil palm plantation. Before dealing with the figures in detail, however, it is necessary to consider the minimum area of land which would have to be planted, if the industry is to be run on modern lines—that is to say, with

the use of machinery for preparing the palm oil and shelling the nuts. The capacity of the machines made by different makers varies. That made by Messrs. A. F. Craig & Co., Ltd., for removing the pulp from the fruits, for example, has a capacity of 3 tons of fruit per hour (see this BULLETIN, 1917, **15**, 71). Assuming that a single machine of this size is employed, the total quantity of fruits required per annum will be 6,000 tons, the number of working days in the year being taken as 200, of ten hours each. From the figures given on p. 246 it will be seen that in the fifth to the tenth years the average annual yield of fruits per tree is 53 lb., and from an acre bearing sixty-four trees the total yield will be 1·51 tons. The area required to produce 6,000 tons will therefore be 4,000 acres. Making allowances for contingencies, it will be safer to take 5,000 acres as the minimum area required to keep a plant of the size mentioned in full working during the first five years the plantation is in bearing. In later years the crop will be larger, and it will be necessary gradually to increase the size of the factory.

The theoretical yields of fruits and oil from an acre of oil palms planted 26 × 26 ft., *i.e.* at sixty-four to the acre, calculated from the figures given on pp. 246–248 are as follows :

	Number of bunches.	Total weight of bunches.	Total weight of fruits.	Total weight of pulp.	Total palm oil.	Total weight of kernels.	Total palm kernel oil.
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
5th to 10th year	768	4·51	1·51	0·906	0·498	0·121	0·060
11th to 30th ,,	640	9·44	4·72	2·826	1·554	0·377	0·189
31st to 50th ,,	192	3·77	1·89	1·134	0·624	0·151	0·075

In calculating the profits obtainable from an oil palm plantation it is necessary to take into consideration not the theoretical yields, as given in the above table, but the practical yields. With modern machinery it should be possible to extract 80 per cent. of the oil contained in the pulp, and the whole of the kernels.

The practical yield, therefore, may be taken to be as follows :

	Palm Oil.		Palm Kernels.	
	Per acre.	Per 5,000 acres.	Per acre.	Per 5,000 acres.
	Tons.	*Tons.*	*Tons.*	*Tons.*
5th to 10th year . .	0·398	1,990	0·121	600
11th to 30th ,, . .	1·243	6,220	0·377	1,880
31st to 50th ,, . .	0·499	2,500	0·151	750

The profits to be derived from an oil palm plantation will depend not only on the yield of fruits, oil and kernels, and the prices obtained, but also on the cost of machinery, land, labour and upkeep. The last three items will vary in different localities, and partly for this reason, and partly because it is difficult to foretell the future course of prices, it is not proposed to give here a precise estimate of the profits that may be anticipated. A fair idea, however, of the profitable nature of an oil palm plantation may be obtained by comparison with a coconut estate. The cost of land, labour and upkeep for any particular locality will be much the same in the two cases, although the initial cost of preparing the land for the oil palm may be less than for the coconut, since the former does well on undulating land, which would not require the drainage operations which are usually necessary on the level coconut lands. On the other hand, the machinery required for preparing the oil palm products is more costly than that needed for preparing the products of the coconut palm (copra and coir).

On the basis of the yields of nuts and copra given by Munro and Brown for Malaya (*A Practical Guide to Coconut Planting*, 1920), one acre under coconuts will yield annually 2,500 nuts giving 0·625 ton of copra, whence an estate of 5,000 acres will produce 3,125 tons. According to Copeland (*The Coconut*, 1914), 1,000 nuts yield 196 lb. of coir, of which 147 lb. are bristle fibre, and 49 lb. mattress fibre; from 5,000 acres, therefore, would be obtained 820 tons of bristle fibre and 270 tons of mattress fibre. The price realised on the estate for the various products is not easy to ascertain, but as the cost of transport and freight will be much the same in all cases for any one locality, it will be sufficient, in order to obtain an idea of the *relative* profits, to take the selling price in England as a basis. For this purpose it is immaterial what price is taken, whether pre-war or current price, since the market price of copra fluctuates in the same degree as palm kernels, whilst that of palm oil also rises or falls in accordance with these, although not quite in the same proportion. The fluctuations in the price of coir need not be taken into consideration, as the revenue

derived from this source is small, compared with that obtained from copra. The following table shows the approximate price that would be realised in England at the present time for the produce of (1) an oil palm estate, and (2) a coconut estate of 5,000 acres each, in full bearing.

Oil Palm	£
6,220 tons palm oil at £61 per ton . . .	379,420
1,880 tons palm kernels at £40 per ton . .	75,200
Total .	£454,620

Coconut	£
3,125 tons copra at £60 per ton . . .	187,500
820 tons bristle fibre at £50 per ton . . .	41,000
270 tons mattress fibre at £18 per ton . .	4,860
Total .	£233,360

As already mentioned, the cost of setting up a factory for the preparation of palm oil and the extraction of the kernels is higher than that needed for preparing copra, whilst an additional expense is involved in the provision of casks or drums for shipping the palm oil. After allowing for these extra costs, however, it will be seen that there is still an ample margin of profit over a coconut undertaking, even if it is found that the yields on a large scale are somewhat below those which are indicated by the results obtained on the oil palm plantations in Sumatra. A further advantage of the oil palm is that, under the conditions obtaining in Malaya and Sumatra, it comes into bearing earlier than the coconut, which does not commonly bear fruit before its seventh year.

A further point to be taken into consideration is the effect on the price of a large expansion in the supplies of palm oil and palm kernels. Hitherto palm oil has been chiefly used in Europe in the manufacture of soap and candles, but, as already mentioned, it is capable of being converted into an edible fat, and if it finds an extended use for this purpose there seems little reason for assuming that an increase in the supply will result in any appreciable fall in price, as compared with other oils used for the same purpose. Even if the bulk of the oil is still used for making soap and candles, its price is likely to remain high, for the employment in the manufacture of margarine of liquid oils formerly mainly used for soap-making has opened up a wider market for palm oil in this direction. The price of palm kernel oil, which is used almost entirely

in the margarine industry, is also unlikely to be seriously affected by an increase in the supply. In any case, it seems preferable to open up plantations of oil palms where conditions are suitable than to extend coconut estates, since the former give a larger return, and any fall in the price of edible fats would affect copra as well as palm kernels and palm oil.

CULTIVATION AND MANUFACTURE OF TOBACCO IN MAURITIUS

Experiments in tobacco growing were undertaken in Mauritius in 1916 at the instance of the Governor, Sir Hesketh Bell, K.C.M.G., with the object of determining whether it would be possible to produce tobacco of the type known as " tabac bleu," which is grown extensively in the neighbouring island of Réunion and is imported into Mauritius in large quantities for local consumption. The annual value of these imports amounts on the average to over one million rupees.

The services of a tobacco expert from Réunion were secured, and work was commenced in October 1916, under the general supervision of the Department of Agriculture. In the 1916–17 season, 2 acres were planted in the Pamplemousses Botanic Garden, 3 acres at Riche-Terre and ½ acre was grown at Beau Bassin by the authorities of the Barkly Asylum. In the 1917–18 season, 3 acres were planted at Pamplemousses, 3 acres at Riche-Terre and ½ acre at La Ferme.

Accounts of the results obtained in these experiments and in subsequent manufacturing trials have been given in *Bulletins Nos. 9 and 15 (General Series) of the Department of Agriculture, Mauritius.* The former of these Bulletins, published in 1917, consists of a report by G. G. Auchinleck, B.Sc., Assistant Director, on " Trials with Réunion Tobacco in 1916–17," whilst the latter gives an account of " Further Trials with the Cultivation and Manufacture of Réunion Tobacco " by H. A. Tempany, D.Sc., Director, and G. G. Auchinleck.

The Réunion tobacco plant (" tabac bleu ") is a hardy

type which produces large, strong leaves of a rich, dark bluish-green colour. This type undergoes very little variation when cultivated and individual plants exhibit scarcely any difference in height, colour and period of maturity, and the average weight of the plants is remarkably constant.

The tobacco is not cured or fermented by the planter, but, immediately after drying, is made into bundles or "carottes" and stored for a period of about two years before it is considered suitable for manufacture.

The tobacco manufactured from the "tabac bleu" variety in Réunion is chiefly a heavy, fine-cut, cigarette tobacco of strong and rather coarse flavour. It meets with a large demand in Mauritius, and is largely smoked by all classes. The tobacco is used to some extent as a filler for cigars which have a wrapper of a firmer leaf, apparently imported from India, but the quality is too coarse for the production of cigars of a high grade and good aroma. In Réunion the tobacco is manufactured into cigarettes, which although coarse and strong are well suited to the taste of the local population.

The trials at Pamplemousses have indicated that the "tabac bleu" is more resistant to disease than types of Virginia, Sumatra and Turkish tobaccos tested previously. The seedlings were attacked to some extent by snails and by a "damping off" fungus (*Pythium de Baryanum*). The young plants were also injured by caterpillars (*Heliothis armigera*) which had to be picked off by hand. A root-disease, probably due to a Fusarium, caused serious damage at Beau Bassin, but this can be controlled by applying lime to the soil and isolating the affected area by means of a trench. Eel-worms (*Heterodera*) appeared in the Pamplemousses plantation, and it seems that the soils of certain localities are severely infested with this pest, and are therefore unsuitable for tobacco growing. Some danger may also be apprehended from leaf-spot disease, which damaged Turkish tobacco grown at Pamplemousses in 1915, but has not hitherto attacked the "tabac bleu" except to a very slight extent. In 1918 the crop at Riche-Terre was reduced by a severe outbreak of tobacco wilt (*Bacillus solanacearum*).

Seed for planting should be carefully selected, and each year a number of vigorous plants should be reserved for seed. It is estimated that 100 plants will yield about 5 kilograms of seed. The seed is sown in boxes or seed-beds, and in about three weeks the seedlings are ready to be removed to the transplanting beds, where they are placed 3 or 4 inches apart and shaded and watered. After three weeks in the transplanting beds, the plants are about 6 inches in height, and can then be set out in the field. At Pamplemousses the plants were arranged at distances of $2\frac{1}{2} \times 1\frac{1}{2}$ ft.; but whilst this is suitable for medium soils, it was found to be too close for the rich soil of Pamplemousses, and it is considered that 3×2 ft. would be more satisfactory in this case. After being planted out, the young plants require to be well tended until they have become established, but subsequently need little attention. Tobacco plants of the Réunion type appear to be particularly sensitive to water, and, provided that the rainfall is fairly evenly distributed throughout the year, irrigation is not necessary. On heavy lands with a high rainfall artificial drainage may prove of advantage.

In Réunion the tobacco is planted in September or October, but the climatic conditions are somewhat different in Mauritius. The best season for planting varies to some extent according to the conditions, but it is essential that there should be a sufficient supply of water available for growth during the early stages, and moderately dry and warm weather at harvesting time. In general, the best months for planting in Mauritius are apparently December–February.

When the plants approach maturity, flowering commences; the flower buds are removed at once in order to check upward growth and thus increase the size of the leaves. Young shoots and suckers in the axils of leaves must also be removed.

The plants are mature about four months after being planted out in the field. They are then cut off within 3 or 4 in. of the ground, and are usually conveyed at once to the drying houses. In cloudy weather, however, they are sometimes allowed to remain for four or five hours on the ground before being removed from the field.

After the plants have been cut, a crop of ratoons may be allowed to arise from the stumps. The ratoons, however, do not yield nearly as much tobacco as the original plants, their production rarely exceeding one-third of that of the latter, and being frequently much less. It seems probable that if ratooning is practised it will not be profitable to harvest more than one ratoon crop.

The yield of green leaf varies greatly with the local conditions. On good soil and with favourable weather and careful cultivation as much as 10 tons per acre may be obtained, but under unfavourable conditions the yield may be as low as 1 ton per acre or even less. On the average, a yield of 3½ to 4 tons of green leaf per acre may be anticipated.

The green tobacco is allowed to remain on bamboo racks in well-ventilated drying sheds for from twelve to fifteen days. The leaves are then broken off the stem and moistened by dipping them into water, and the principal portion of the midrib is removed. The leaves, while still moist, are next made into small twisted packets or "rouleaux," each weighing about 1½ to 2 lb., and the rouleaux are subsequently packed into "carottes." A carotte consists of a torpedo-shaped bundle, 18 to 22 lb. in weight, covered with a wrapping of dry banana leaves, known as "empondres," and tightly bound externally with sisal cord. The carottes are unwound and rewound from time to time at gradually increasing intervals. The winding is done with considerable force, and when done for the last time so much pressure is exerted that the resultant carotte is quite hard and rigid. The carottes are stored for 1 to 2 years, and the tobacco is then ready for manufacture. This method of curing the tobacco in carottes is a process of slow oxidation, resulting in the destruction of the greater part of the nicotine and the production of organic acids, principally butyric acid, and tarry matter, to which the dark colour of the finished product is due.

The carottes are generally classed in three grades; those of Grade I are made from the largest and finest leaves, and take longer to cure than the lower grades, whilst those of Grades II and III are made of leaves of poorer quality, and yield an inferior product.

In 1919 manufacturing and commercial trials were made with considerable success in a specially equipped factory at St. Louis, and showed that tobacco manufactured from the Mauritius leaf realised approximately the same price as that imported from Réunion.

The yield of cured carotted tobacco amounts to about 10 per cent. of the weight of the green leaf, and the manufactured tobacco to about 34 per cent. of that of the cured carotted tobacco or 3·4 per cent. of the weight of the green leaf.

The development of the industry is hampered by the fact that, owing to lack of organisation, growers cannot readily find a market for their crop, and also by the difficulty of popularising the Mauritius-grown tobacco in competition with the established marks of Réunion tobacco. The Government therefore propose to establish buying stations for the purchase of the green leaf at 10 cents. per kilogram, a price which it is estimated will yield a profit to the growers of about Rs. 130 per acre. The leaf will be carotted, manufactured and sold under the auspices of the Department of Agriculture. This action will only be temporary, for it is intended that as soon as the industry has been placed on a successful basis it shall be transferred to the ordinary channels of trade.

LOCUSTS AND THEIR CONTROL

Of all the plagues with which man has had to contend in his efforts to utilise and develop the vegetable resources of the world, few have been more catastrophic in their incidence or apparently more erratic in their occurrence than the visitations of locusts.

Numerous methods have been used in different countries, with varying degrees of success, for combating the pest, but it is only in recent years that any systematic work has been carried out on the subject. Such work is rendered difficult by the fact that in any particular country the pest is not always present, but at uncertain intervals becomes a serious menace, requiring to be dealt with by the most practicable means immediately available, and such

advances in knowledge as have been made are mainly the result of "trial and error" rather than of co-ordinated work on scientific lines.

The term "locust" is not everywhere used with the same connotation, but generally speaking it is applied to those members of the family *Acridiidae* which are swarming and migratory in habit and highly destructive to vegetation.

There is some confusion regarding the nomenclature and systematic identities of the locusts that are met with in different parts of the world, and no attempt is made in this article to give a list of the different species and the countries in which they occur. For full accounts of the biology of the insect reference must be made to works on entomology. It is essential, however, in order to combat the pest successfully, to know something of the life-history of the insect.

Life-history and Biology of Locusts

The eggs are laid in the earth in clusters or masses. The number of eggs in a cluster is variable ; in the case of the Egyptian locust it is generally between 80 and 120, averaging about 100, while in other countries smaller numbers are reported as the general rule.

The female, when about to lay, curves her abdomen, which becomes greatly extended, inserts the end into the ground, and proceeds by means of a special apparatus to dig a tubular hole, commonly about two or three inches in depth. The eggs are deposited in this hole, and the remainder of the space is then filled with a white frothy material, which soon hardens, forming a protection to the eggs during their period of incubation.

The eggs hatch in a period generally between sixteen and thirty-six days. The larvæ which emerge are at first comparatively inactive, but soon develop voracious appetites and the habit of hopping. In this stage they are known as "hoppers."

During the "hopper" period they undergo a series of moults, usually four or five in number, increasing progressively in size, until at the final moult they become winged insects. When moulting the hopper attaches itself,

head downwards, to a twig or other support. For a short time immediately before and after moulting the insect suffers a temporary reduction of appetite.

The time from hatching to the final moult varies in different species; it is generally between thirty-two and fifty days, but both shorter and longer periods have been recorded.

After the insects have become winged they continue their devastatory progress with increased rapidity. Both hoppers on the march and flight locusts on the wing commonly proceed in armies, as though urged in a particular direction by a common impulse.

The factors determining the direction of progression of an army of locusts do not appear to have been definitely ascertained. According to the *Report on the Great Invasion of Locusts in Egypt in 1915*, published by the Egyptian Ministry of Agriculture, "swarms, when flying, take up a definite position as regards the wind. In a gentle breeze they fly directly up the wind; if the wind strengthens they immediately respond by changing their direction to a diagonal to the wind. In a moderately strong wind they will be observed flying at right angles to the wind direction, and as the wind velocity increases their line of flight is turned more and more, until we find them flying down the wind when a gale is blowing."

The direction of motion of locusts while they are in the hopper stage is stated to be practically uninfluenced by the wind.

Flight locusts generally travel mainly by day and rest at night, though in some cases they have been observed flying at night.

It has been stated by several writers that the female dies soon after the eggs have been laid, and the male soon after copulation; contrary statements on both these points are, however, also made, and it is recorded that in some species the female lays two or more egg-masses in a season.

It has long been a common belief that locusts' eggs may hatch out after remaining in the ground for several years. It has been found that eggs kept dry in tins or jars could be caused to hatch after a number of years

by being moistened and exposed to suitable conditions of temperature, and it appears to be an established fact that this does sometimes occur under natural conditions.

Natural Enemies of the Locust

Reference may be made here to the natural agencies tending to the destruction of locusts ; though it will be understood that as one pair of locusts may produce about a hundred in the next generation, the destruction from all these causes together cannot be of great practical importance when conditions are otherwise favourable to the pest.

Rain is probably one of the chief agencies destroying locusts, particularly when they are in the hopper stage. The wet tends to clog the breathing pores of the body and so suffocate the insect. Submersion under water of areas in which eggs have been laid, or even their thorough soaking with rain, generally has the effect of preventing the eggs hatching. Moisture is also a factor favourable to the spread of bacterial disease in locust swarms.

Armies of flying locusts are stated to be not infrequently destroyed, or greatly reduced in numbers, by being drowned while crossing the sea, as a result of exhaustion from battling with adverse winds.

Predatory animals have quite an appreciable effect in keeping down the numbers of locusts. They are of course different in different countries. For the most part they are birds, among which may be mentioned storks, guinea-fowls, ducks, turkeys, kites, kestrels, hawks, kingfishers, blackbirds, crows, grouse, sparrows, swallows, larks, starlings and shrikes. Other animals that are stated in various countries to devour locusts include dogs, pigs, monkeys, squirrels, rats, mice, frogs, toads and various kinds of snakes. The eggs are devoured by ravens and crows, lizards, and certain beetles, wasps and ants.

There are in addition a number of parasites preying on the insect, such as hair-worms, mites, and flies of various kinds, as well as several egg parasites. Locusts are also subject to diseases of bacterial and fungoid origin. Attempts have been made to use these as means of artificially checking the pest ; reference to this subject will be found in a later section of this article.

It is also well established that locusts are cannibalistic. Dead locusts are commonly consumed by their survivors, and in times of scarcity of food the insects will kill and devour each other.

It has been proposed that animals, particularly birds, that destroy locusts should be deliberately encouraged for the purpose. It hardly seems likely that such repressive agents could ever become sufficiently effective in the case of severe visitations to obviate the necessity for adopting more direct artificial methods, but where such animals are found they should at least be protected.

Methods of Control

It may be stated generally that it is of the utmost importance to destroy the insects in as early a stage as possible. If practicable the eggs should be destroyed, though in practice it has generally not been found possible to do this completely, a certain proportion of the eggs escaping destruction. The most practicable stage in which to deal with the pest is the hopper period ; if the insects reach the flying stage they are then much more difficult to deal with, and moreover the plague spreads owing to eggs being deposited over new areas.

The methods used for checking the pest may be described under the following general headings : (1) Destruction of eggs. (2) Trapping, driving, crushing and burning of hoppers. (3) Collection and driving of winged locusts. (4) Spraying and poisoning. (5) Bacterial and fungoid diseases.

Destruction of Eggs

This is a method that does not in principle present very serious difficulties, the egg masses being generally deposited closely in fairly well-defined areas, but it is somewhat laborious, and its practicability in any particular country depends upon the available supply of labour.

If sufficient labour is available the eggs may be dug up and destroyed ; simple exposure to the sun, or even the disturbance of digging up, is generally sufficient to kill them, provided their development has not proceeded too far. The egg-masses are readily located immediately after

laying by the white appearance of the frothy secretion; soon, however, this may become obscured by dust or obliterated by rain, when the eggs are less easy to find.

In the early days of the British administration in Cyprus the locust plague was one of the most serious problems to be dealt with, the produce of the island being devoured every few years, and every able-bodied man on the island was therefore required, by way of tax, to collect and bring to the authorities a certain weight of eggs. In spite of the enormous number that were thus collected and destroyed, the plague was not appreciably arrested; attention was therefore turned to other methods, and the Mattei "screen and pit" method, described on page 262, was adopted in 1881.

In Turkestan eggs were collected and destroyed on an extensive scale for some years, but the practice was discontinued as it was not found sufficiently effective, locusts hatching out in considerable numbers in all the areas that had been traversed. When it is considered that the chief species of locust in Turkestan lays eggs in quantities that may attain to 10,000 clusters per square yard, it will be realised that in practice it would be impossible to avoid missing any of the eggs over an egg-laying area which commonly covers hundreds of acres and may extend to thousands.

In Egypt and other countries the collection of eggs has been encouraged by payment.

The system of payment for eggs, or enforced collection of eggs, is of course open to abuses and evasion. Thus during an invasion of locusts in Syria in 1915 all male inhabitants between sixteen and sixty years of age were required to collect eleven pounds of eggs. Imitation eggs were made from white clay and brought to the authorities, who, according to an article in *The National Geographic Magazine* for December 1915, accepted them without question.

Flooding the ground in which eggs are deposited is a very efficient means of killing them. When this method can be applied it is probably the most effective, but it is of course not always practicable. Mere irrigation is not always sufficient; indeed it is alleged that in some parts

of Egypt where irrigation was tried it actually had the effect of assisting hatching, at least in cases where the eggs had already reached an advanced degree of development.

Eggs can often be destroyed, or buried so effectively that the hoppers on hatching are unable to escape from the earth, by thoroughly ploughing the breeding areas, and subsequently rolling or stamping, but this method can hardly be regarded as entirely reliable, a certain proportion of the eggs necessarily escaping the plough.

In Italy it has been recommended, in cases where cultivable land is infested with locust eggs, that the areas affected should be ploughed, and afterwards sown with a winter cereal crop. This is stated to destroy the eggs completely, and has the advantage of costing nothing.

Destruction of Hoppers

The trapping of locusts by means of screens and pits has been successfully carried out in several countries. It can only be applied to locusts in the hopper stage.

The method proposed by Mr. R. Mattei and first adopted in Cyprus in 1881 consists in employing long screens of canvas or calico, about a yard high, stretched on stakes driven into the ground. The lower edge of the screen rests on the ground, being covered with earth for an inch or two, and stitched along the top edge is a strip of oil-cloth about four inches wide. Long lines of these screens are erected in the line of march of the hoppers, or near the areas where eggs have been deposited, so that as soon as the hoppers hatch and begin to move away they can be driven against the screens. In front of the line of screens is dug a series of pits, each about a yard deep. The pits run at right angles to the screens, and are separated from each other by distances of seven yards or more. Round the edges of each pit are strips of tin or zinc, so fixed that hoppers falling into the pits are prevented from escaping. The insects, being unable to pass the screens, hop about till they fall into the pits. When the pits are sufficiently full of locusts they are filled up with earth by men stationed for the purpose, and the earth is trampled down. Fresh pits can then be dug and the process continued. The oil-cloth has the effect of causing any hoppers that may crawl

up the screen to lose their hold and fall back to the ground. If necessary the oil-cloth can be wiped with an oily rag to keep it in a slippery condition.

After this method had been in use in Cyprus for about five years the locust plague was more or less under control, but its use was not discontinued till 1897. At the present time locusts are no longer such a serious menace in the island (cf. this BULLETIN, 1919, **17**, 316).

Other systems of trapping hoppers do not differ fundamentally from the Mattei method. In many cases it has been found that screens are unnecessary, the hoppers simply being driven into trenches, which are then filled in and the earth trodden down. Trenches alone, without screens, are generally sufficient when the hoppers are quite young. This method is the one chiefly employed in Egypt, where the use of chemical poisons (described on page 266) has not been found well adapted to local conditions.

When hoppers have to be driven, this is effected by beating the ground behind them with sticks or branches. It is a common practice in some countries to accompany the driving by the beating of empty tins or otherwise making a noise, but this is of doubtful utility. It is important not to drive the hoppers too fast, as they may become exhausted, and are then apt to hide in crevices, and so be passed over. Young hoppers can be driven in any direction desired, but after about the first two moults they tend to move in a body in one direction, and it is then difficult to make them move in any direction other than that in which they are collectively travelling.

In the United States special machines known as "hopper-dozers" are used for collecting and killing hoppers. The essential part of this arrangement is a long pan made of sheet iron about two feet wide and ten or fifteen feet long, which is dragged over the ground in a direction at right angles to its length. The foremost edge is nearly level with the ground, and is only turned up a few inches; the rim at the back is deeper, and is surmounted by a canvas screen or hood. The bottom of the pan contains oil, or water with oil floating on it. The arrangement is drawn across the swarm of hoppers, against the direction of their motion, either by two men, one at

each end, or in the case of larger "hopper-dozers" by two horses. The hoppers jump as the machine reaches them, fall into the pan and are killed by contact with the oil. This arrangement cannot, of course, be used on rough ground or where there are many trees or stumps.

In Hungary sweeping machines have been effectively employed against locusts in the hopper stage. The machine consists of a pair of wheels, with a seat for a driver, and a wooden bar at the back carrying a brush or rake consisting of steel teeth about six inches long. In the front are a pair of shafts, the whole width of the machine apart. Two horses are harnessed to the outsides of these shafts, so that when drawing the sweeping-machine they do not tread on the ground that will be swept by the brushes. In covering an area infested with hoppers a number of these machines are commonly employed, one diagonally behind another; the path of each one slightly overlaps that of the one in front, so that none of the ground escapes the brush. It is usual to begin operations at the edges of the area to be treated, the hoppers being thus driven to the centre. If one sweeping is not sufficient to kill all the hoppers, the machines are again passed over the area. This method, like the last, can only be used on level ground.

In some countries rollers or heavy logs of wood are drawn over the ground to crush the hoppers. The effectiveness of this method depends on the nature of the ground and the vegetation.

Bag-nets of various descriptions, drawn over the ground either by men or between horses or bullocks, have also been used with varying success. The part of the rim of the net that sweeps the ground is kept flat by means of a straight stick, and the mouth is kept open by a bow-shaped piece of wood or other suitable arrangement. The hoppers thus collected at the closed end of the net can be killed by crushing, or by immersion in hot water, or by any other convenient means. This method has been used in Cyprus, India and Argentina.

If hoppers are aggregated in large numbers in sufficiently dry vegetation, they can be destroyed by burning. It is worth noting that on level ground hoppers tend to

gather in crowds on any slight elevation, such as a heap of stones or a pile of dry vegetation. This affords an obvious method of collecting them with a view to their destruction by burning or otherwise. It has been found, however, in the Federated Malay States that a lalang area infested with hoppers may be burnt and only a small proportion of the hoppers killed, the insects falling to the ground as the fire reaches them and remaining unhurt.

In Turkestan hoppers are destroyed by directing jets of burning oil on them by means of special knapsack apparatus. The chief objection to this method is its costliness, but it can be employed where other methods are for any reason impracticable.

Collection and Driving of Winged Locusts

In some cases it has been found possible to effect some destruction of winged locusts. In the early morning, flight locusts are generally to be found congregated in a semi-torpid state on the ground in open places or on trees. In this condition they can be swept up or beaten off the trees into nets or bags, and destroyed. This plan was adopted with success in Egypt in 1915, when some 13,500 tons of locusts, representing 7,866,000,000 individuals, were collected and burnt in the fields. On this occasion a payment of one millième per oke (equivalent to about 1*d.* per 11 lb.) was made for captured locusts.

In cases where winged locusts are in crops and cannot be destroyed without damaging the crops, it is often possible by continually worrying them to drive them away from cultivated land into forests where they can satisfy their appetites without doing such serious damage. This method is commonly adopted in the Northern Bengal Himalayas in dealing with invasions of flight locusts. These invasions are of frequent occurrence, but the species of locust concerned is one requiring a dry sandy place in which to deposit its eggs; it is therefore sufficient to drive the locusts from the fields into the surrounding jungle, where the humid conditions are unfavourable to reproduction, and the insects soon die without laying.

Spraying and Poisoning

The use of chemical poisons, applied in the field, is probably on the whole the method that is most generally applicable.

Various mixtures are recommended, most of which contain arsenic. The following standard formula is that adopted in South Africa, where the arsenic method has been elaborated and is regarded as superior to all other methods ; the mixture is also used in other countries with success.

Arsenite of soda	1 lb.
Sugar or treacle	2–4 lb.
Water	16 gallons

This preparation is recommended for hoppers in the earliest stages ; for older insects the strength should be increased, a solution of double the above strength being employed for large hoppers.

Solutions both stronger and weaker than the above have also been advocated as results of practical trials under various conditions.

The mixture should be sprayed in a fine mist on to the grass or other vegetation where the locusts are present. In the case of very young hoppers it is applied to the ground where they are feeding, or in a circle round them ; with larger hoppers that have begun to travel it is best sprayed on to the vegetation in front of them. Spraying is most conveniently carried out at night or in the very early morning, while the hoppers are resting. Any convenient spraying machine may be used, preferably one fitted with a nozzle of the " Bordeaux " type.

The chief objection to the use of arsenic solutions is the risk of poisoning animals, and it is necessary to prevent animals eating grass that has been sprayed. The risk is to some extent lessened by the fact that if the arsenic mixture remains on the grass it causes it to die, thus ceasing to be attractive to animals, while a heavy rain washes the poison into the ground. The fact remains, however, that in districts where arsenic is used it is not uncommon for cases of poisoning among cattle to occur, and it is very necessary to impress on all concerned the need for caution.

The use of poison baits in preference to broadcast spraying is at present frequently advocated, and has much to recommend it. Where this method is employed vegetation is not harmed, cattle can be more easily protected, and considerably less material is required.

The poison employed is usually an arsenic compound, and as a basis for the bait any suitable material can be used. Shredded sugar cane poisoned with arsenic was successfully used in South Africa as early as 1896. Horse manure has been found attractive to young hoppers, and was used, in admixture with arsenic and common salt, in the " Criddle mixture " which was successfully employed in Canada against outbreaks of locusts at the beginning of the present century. Crushed locusts steeped in poison solution are also stated to form an attractive bait, the cannibalistic tendencies of the insect being well known. Bran is commonly recommended as a convenient vehicle for the poison, molasses being added in order to make the bait attractive.

A formula for bran bait, which is stated to have been successfully used in the United States and Canada, is the following :

Bran	50 lb.
Paris green or white arsenic . .	2 lb.
Molasses	4 quarts
Oranges or lemons . . .	6 fruits
Water	5–6 gallons

The juice and the cut-up pulp and peel of the fruits, together with the molasses, are added to the water, which is then poured over the bran and poison, previously mixed together ; the whole is then thoroughly stirred.

Locusts poisoned by arsenic generally die within two or three days.

It should be mentioned that in Egypt, where much useful work on the destruction of locusts has been carried out, arsenic poisoning is not used. This is owing to the special conditions in that country. Practically the only vegetation present consists of cultivated crops, and it is therefore not practicable to apply some of the methods that have proved successful in pastoral countries. The only satisfactory procedure is to destroy the insects in

the very earliest stages, before they begin to feed, a fact which makes it impossible to use stomach poisons. The destruction is effected partly by collecting the eggs, and more particularly by trapping the young hoppers in trenches, methods rendered possible and effective by the abundance of labour available in Egypt.

Another method of destroying hoppers is to spray them with soap or oil preparations. These act by clogging the insects' breathing organs, and are therefore known as "contact poisons" in contradistinction to arsenical and other mixtures which have to be eaten by the insects and are designated "stomach poisons."

Formulae recommended are:

(1)	Hard soap	1 lb.
	Water	5 gallons
(2)	Kerosene	1 gallon
	Water	7 gallons

The second of these requires the use of a spray-pump having an automatic mixer. This necessity is obviated by using a kerosene "emulsion," a formula for which is as follows:

(3)	Kerosene	1 gallon
	Hard soap	½ lb.
	Water	8 gallons

The soap should be dissolved in hot water, the kerosene added and the whole thoroughly mixed.

The chief objection to the use of kerosene is its cost.

Contact sprays are most effective with young hoppers, though it is stated that kerosene can be used effectively on winged locusts while resting at night. They must be used sufficiently liberally to wet the insects thoroughly. They have the advantage over arsenical preparations of not being poisonous to cattle or harmful to crops.

Bacterial and Fungoid Diseases

The use of the bacterium *Coccobacillus acridiorum* as a means of causing the destruction of locusts by disease was proposed, and practical trials to this end were described by its discoverer, F. H. d'Hérelle, in the *Comptes Rendus*

de l'Académie des Sciences (1911, **152**, 1413; 1912, **154**, 623). A note dealing with the process was published in this BULLETIN (1914, **12**, 471), where reference was made to the successful results obtained in Argentina by M. d'Hérelle, who carried out trials on behalf of the Argentine Government. Trials in other countries gave less convincing results.

Further experimental work has been reported, but it cannot be said that the process seems likely to prove of general practical utility.

The chief obstacles to its use appear to be: (1) the fact that the culture has to be passed through a series of about twelve locusts in order to attain a sufficient degree of virulence, an operation which takes up time during which the insects are doing damage, and which cannot well be carried out except by a bacteriologist; (2) the difficulty in realising, under very diverse circumstances, the precise conditions most favourable to its efficacy; and (3) the fact that locusts may display a certain degree of immunity to the disease.

The last fact was emphasised in the case of the Egyptian invasion of 1915, when a considerable proportion of the insects were found on arrival to be infected with the bacillus. A certain number died from this cause, but the swarm as a whole did not appear to be appreciably affected, showing that it is possible for locusts to enjoy a considerable degree of immunity, at least in the case of mild forms of the disease.

In Algeria the method has been used on a practical scale. A fairly high mortality was reached, but it was not found possible to cause the complete destruction of a swarm.

In Morocco experimental campaigns have been carried out, but the method is not there regarded as more than a supplementary means of dealing with the locust pest, on account of the practical difficulties in attaining in the field the ideal conditions for the spread of the disease.

In Eastern Canada experiments have been made both in the laboratory and in the field, and the conclusion has been reached that the method is not suited to Eastern Canadian conditions.

In Italy the process has not been found to produce a sufficient degree of mortality to warrant its adoption.

In Cyprus, in spite of the fairly successful results that were obtained with the d'Hérelle bacillus, the egg-purchase system and the use of arsenite of soda as a poison are the methods at present regularly adopted.

The method, therefore, cannot as yet be said to rank as one of generally proved efficacy. It has, however, the advantage of being inexpensive, and it is to be recommended that further trials should be given to it as occasion may arise. The culture can be obtained, with instructions for its use, from the Pasteur Institute, Paris. Its efficacy probably depends on climatic conditions, atmospheric humidity and the absence of sunlight being favourable to the spread of the disease, and it is quite possible that under favourable conditions the process will prove a valuable auxiliary means of combating the locust plague.

Reference may be made here to the "locust fungus" (*Empusa Grylli*, Fres.). This was found to be the cause of death of considerable numbers of locusts in South Africa, and attempts were made to prepare cultures of the fungus for distribution with a view to its use for spreading the infection among locust swarms. Cultures were prepared and trials were carried out with them in several countries, notably in India, but they were found to be quite ineffective, the cultures distributed being in fact not *Empusa Grylli*, which is stated to require living tissue for its development and to be incapable of successful growth in artificial media; but other fungi, chiefly one not previously known which was named *Mucor exitiosus*, Massee, at Kew; this organism is purely saprophytic in habit and quite innocuous to living locusts.

Whatever means be selected for dealing with an outbreak or invasion of locusts, the most important factors are organisation and co-operation. Action taken by individual planters or in particular districts is practically useless, except as part of a general plan of campaign, which should have been prepared in advance without waiting till a sudden visitation has to be met by the hurried adoption of panic measures.

RAW MATERIALS FOR THE CERAMIC INDUSTRY IN SOUTH AFRICA

CLAYS of various types are widely distributed in the Union of South Africa and have long been utilised to some extent for the manufacture of bricks, tiles, earthenware, pottery ware, etc. Large quantities of ceramic manufactures also are imported from overseas, chiefly from the United Kingdom. The value of these imports in 1913 amounted in the aggregate to £181,179, the chief items being earthenware and chinaware (£153,266), pipes and piping (£8,678) and roofing tiles (£7,003). In 1918 the total value of the imports was £185,801, but this increase was due entirely to an increase in the value of the earthenware and chinaware imported, the imports of all other articles being less than in 1913.

According to the Census returns for 1916–17 the total value of all ceramic articles manufactured in the Union in that year amounted to £325,951, the chief articles being bricks (£217,535), earthenware and pottery (£59,749), firebricks (£29,750), and tiles (£13,288). The principal centres of the ceramic industry are Witwatersrand in the Transvaal and the Cape Peninsula. Of the 117 factories in the Union in 1916–17, 49 were located in the Transvaal, 40 in the Cape Province, 17 in Natal and 11 in the Orange Free State. On the whole the ceramic industry made little or no progress during the war; the manufacture of building bricks naturally fell off, but the manufacture of firebricks, fancy bricks and crucibles increased, whilst an impetus was given to the manufacture of roofing tiles, owing to the high price of corrugated iron, which was formerly the favourite roofing material.

There seems no reason why much, if not all, of the ceramic manufactures at present imported into the Union should not be produced locally, and attention is directed in the present article to deposits of clays and other raw materials, which could be utilised for this purpose. A useful account of the present position of the ceramic industry in the Union is given in *Industries Bulletin, No. 7*, issued by the Ministry of Mines and Industries, Pretoria.

Clays

Transvaal

Pottery Clays.—Most of the coal measure clays are said to be suitable for pottery work.

A deposit of these clays occurs at Olifantsfontein, and was worked on a small scale before the Anglo-Boer war. Since 1903, when the property was acquired by the Consolidated Sand Brick and Pottery Co., Ltd., it has formed the basis of an important firebrick and earthenware industry.

During 1912, earthenware, tiles, mosaic and sanitary ware to the value of £12,560 were produced at this works. The portion of the works producing earthenware and glazed tiles was closed in 1914. So far as information is available this is the only works in South Africa that has produced general earthenware of a white body. A layer of clay similar to English ball-clay occurs in this deposit.

Brick, Tile and Terra-cotta Clay.—Good common clay for brickmaking is almost universal throughout the Union, and near the large industrial centres beds of shale occur, which are suitable for the manufacture of pipes, tiles, etc.

Bricks are made at Pretoria, Johannesburg, Turffontein and Olifantsfontein. Tiles and terra-cotta are made at Pretoria, Turffontein and Vereeniging from local clays. At Kirkness Brickyard, near Pretoria, bricks are made of a mixture of crushed Timeball Hill shale and a small proportion of dark clayey loam occurring in an old channel of the Aapies River.

Clay occurs south and south-west of Pretoria in the hollows between the two quartzite ridges of the Timeball Hill series. It is mainly yellow or red in colour, though a whitish clay also occurs.

Fireclays.—These occur associated with all the coal measures of the country. Firebricks and crucibles are being manufactured from such clays near Boksburg.

The following are analyses of clays taken from the pits of the Boksburg Brick and Fireclay Company:

—	I.	II.	III.	IV.
Silica, free	nil	nil	65·40 (free and combined)	87·60
Silica, combined	48·40	44·70		
Alumina	37·00	41·60	25·60	9·10
Ferric oxide / Ferrous oxide	1·10	0·40	0·50	0·40
Lime	—	—	—	—
Magnesia	trace	trace	trace	—
Alkalies	—	—	—	—
Water	14·30	14·40	9·40	3·40
Total	100·80	101·10	100·95	100·50

I. Cane-coloured fireclay.
II. Whitish-coloured fireclay.
III. Plastic clay in pockets.
IV. Ganister, forming the matrix of Dwyka conglomerate.

Fireclay of satisfactory quality is said to have been discovered in the town lands of Wakkerstroom. Vereeniging fireclay has been reported by the Leeds Fireclay Company to be equal in refractoriness to the best Stourbridge fireclay. The Olifantsfontein clays are also characterised by great refractoriness. The following analyses show their composition in comparison with the well-known Stourbridge fireclay:

-	I.	II.	III	IV.	V.	VI.
Silica (free)	nil	nil	nil	8·91	35·47	65·10 (free and combined)
Silica (combined)	43·64	45·46	45·19	40·10	28·92	
Alumina	39·16	38·36	38·73	33·93	24·44	22·22
Ferric oxide / Ferrous oxide	1·53	1·87	0·52	2·63	1·74	1·92
Lime	0·30	0·00	0·26	0·26	0·30	0·14
Magnesia	0·34	0·27	0·22	0·32	0·00	0·18
Alkalies	0·47	0·31	0·94	0·62	0·45	0·18
Sulphuric anhydride	1·00	0·39	0·01	0·24	0·00	—
Loss on ignition	13·56	13·34	14·07	12·99	8·68	10·40
Total	100·00	100·00	100·00	100·00	100·00	100·14

I, II, III, IV. Olifantsfontein fireclays.
V. Clayey sandstone, Olifantsfontein.
VI. Stourbridge fireclay.

The portion of the Olifantsfontein works manufacturing fireclay and stoneware goods is still in operation.

Kaolin.—This does not appear to have been worked in the Transvaal, and none has been discovered equal to the European kaolins.

The factory at Olifantsfontein used a clay from Krugersdorp, and another from near Cape Town which fired quite white, and both of these proved satisfactory.

A sample of kaolin from the Rustenburg district was examined at the Imperial Institute. The washed material, which constituted 88 per cent. of the original sample, had the following composition :

	Per cent.
Silica	61·91
Ferric oxide	0·11
Ferrous oxide	nil
Alumina	26·43
Lime	0·74
Magnesia	0·45
Titanium dioxide	1·26
Potash	3·72
Soda	0·92
Loss on ignition	4·15

This clay, mixed with Cornish stone and flint, gave a coarse porcelain when fired at a temperature of about 1,370° C., but the colour was not a good white. The clay was not sufficiently plastic to work on the potter's wheel, but it could probably be used for the manufacture of stoneware. The washed clay is inferior to Cornish kaolin, as it contains a considerably higher percentage of silica and does not give a good white porcelain. It also differs from Cornish kaolin in showing fair plasticity when wet.

Natal

Brick, Tile and Terra-cotta Clay.—Brick clays are not common in the Colony, but very fair bricks are made at Maritzburg by grinding Ecca shales with alluvium brought down by the Umsindusi River. The shales at Omgeni near Durban are utilised for bricks and tiles. The best-known clay deposit is that in the Maritzburg valley, where bricks and roofing tiles are made. Many clays occur between Sarnia and Drummond on the Durban-Maritzburg line, and also at Avoca Valley and Balgowan.

Fireclay.—Near Gezubuso station, on the Natal-Cape line, micaceous sandy shales are ground up with a hard felspathic quartzite to make firebricks. A fairly large number of firebricks is produced annually. Grey shales somewhat lacking in plasticity are found at Hilton Road.

Kaolin.—Extensive deposits of kaolin occur in the granite area round Paulpietersburg. Kaolin also occurs near Padley's Station. It is fairly free from quartz, but the deposit does not appear to be very thick. The water necessary for washing purposes seems to be rather scarce.

A deposit in the neighbourhood of Edendale, 2½ miles from the Natal-Cape railway line, was analysed at the Imperial Institute, with the following result:

	Per cent.
Silica	52·09
Ferric oxide	0·48
Ferrous oxide	0·62
Alumina	34·28
Lime	nil
Magnesia	nil
Potash	1·23
Soda	0·64
Water	11·02

This kaolin when mixed with water formed a paste which was plastic and could be moulded. When mixed with more water to form a slip it showed a tendency to flocculate and sedimented quickly, in this respect differing markedly from English kaolin. On this account the material was difficult to cast, and on drying the shape was more apt to develop cracks than most kaolin mixtures.

Tests were made with the kaolin alone, and after mixing with the other ingredients used for making English porcelain. After firing, the kaolin yielded a biscuit which had a decidedly yellow tint and compared unfavourably with a biscuit made from English kaolin. The porcelain mixture, which was fired at 1,350° C., furnished a product of dull colour and almost opaque. Kaolin of this quality, therefore, would be of no value for the manufacture of ordinary porcelain, and could only be used for the production of the poorer qualities of earthenware.

A firm of commercial experts to whom samples of the Edendale kaolin and the porcelain made from it were submitted in 1908, reported that it was of poor quality, and worth at that time about 15*s.* per ton in this country. Kaolin represented by this sample would no doubt be of use for the local manufacture of earthenware.

The occurrence of kaolin in this locality is of interest, and further search might be made with a view to the discovery of better material.

There is also a small deposit of kaolin at Qwakubeni, near Katshís Kraal, twelve miles south-west of Pietermaritzburg.

Cape Province

Brick, Tile and Terra-cotta Clay.—Clays occur on Cape Flats and at Grahamstown. The Uitenhage formation contains much clay in the region between Algoa Bay and the mountains near Uitenhage. There is also much clay in the country between Mossel Bay and Heidelberg. Common bricks and roofing tiles are made in the latter district. Fine grades of clay have been obtained in the Somerset West district.

Fireclay.—Beds of fireclay are associated with some of the coal seams of the Molteno beds, and at Cyfergat a seam is being mined for the manufacture of bricks. Thick beds of fireclay have been found underlying a seam of coal just north of Sterkstroom and underlying the coal of the Guba Valley, near Indwe.

Kaolin.—Occurs on Cape Flats, but has been found difficult to use on account of excessive shrinkage. Specimens of pure kaolin have been taken from the Upper Witteberg rocks near Grahamstown.

Kaolin of good quality is found near Steinkop in Little Namaqualand. An analysis of a sample sent to the Imperial Institute gave the following result:

	Per cent.
Silica	59·71
Ferric oxide	trace
Alumina	29·92
Titanium dioxide	0·72
Lime	nil
Magnesia	0·34
Potash	3·91
Soda	0·60
Moisture at 110° C.	0·34
Combined water	5·27

The percentage of silica in this clay is much higher than in the case of a pure china clay, and the material

would not be found equal to Cornish kaolin. The results of a technical trial indicated that the material could be used for the manufacture of porcelain. It is stated that the quantity of kaolin in the deposit appears to be practically unlimited.

Samples of kaolin received at the Imperial Institute from Firmondium and Kingwilliamstown district were washed. The washed materials, which constituted 44 per cent. and 43 per cent. respectively of the original, had the following composition :

	Firmondium. *Per cent.*	Kingwilliamstown. *Per cent.*
Silica	64·36	57·14
Ferric oxide	3·16	1·78
Ferrous oxide	—	0·13
Alumina	21·25	27·60
Lime	0·53	0·20
Magnesia	0·80	1·08
Titanium dioxide	0·48	0·92
Potash	2·07	0·74
Soda	1·43	1·90
Loss on ignition	6·16	9·03

It is unlikely that the crude material represented by the sample from Firmondium would be of any value for the manufacture of pottery or porcelain, owing to the quantities of silica and iron present.

The washed clay from Kingwilliamstown was of a yellowish-white tint, and was inferior to good kaolin in colour. It was less plastic than good Dorset clay, but was still plastic enough to be worked. The washed clay is quite suitable for the manufacture of all but the best grades of white pottery or porcelain.

A sample of white clay from the Van Rhynsdorp district analysed at the Imperial Institute had the following composition :

	Per cent.
Silica	67·89
Ferric oxide	—
Alumina	21·36
Lime	0·92
Magnesia	0·66
Titanium dioxide	1·00
Potash	2·57
Soda	0·53
Loss on ignition	5·30

Orange Free State

The following analyses of clays formerly worked by the Marseilles Tile and Pottery Co. (S. Africa), Limited, were made by E. V. Floek, Government Analyst:

—	I.	II.	III.	IV.	V.	VI.
Natural colour	red	blue	white	cream	yellow	terra-cotta
Fired colour	red	white	white	cream	red	red
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	5·47	5·45	1·34	3·15	2·27	6·25
Loss on heating	5·30	5·56	3·07	4·42	3·96	4·91
Silica	58·00	60·18	78·64	66·00	67·05	68·38
Oxide of iron	8·25	trace	trace	trace	6·23	13·75
Alumina	19·80	26·32	16·52	28·87	18·00	5·82
Lime	0·22	0·20	0·07	0·32	0·20	0·10
Magnesia	0·95	0·53	0·11	0·52	0·77	0·28
Undetermined (alkalies, etc.)	2·01	1·76	0·25	1·72	1·53	0·11

Other Ceramic Materials and Manufactures in the Union

Quartz.—Quartz free from iron is obtained from a large vein of pure quartz in the grounds of the Modderfontein Dynamite Factory.

Silica bricks are made at Vereeniging and Boksburg from Transvaal quartz. The following analyses show the composition of a Vereeniging brick compared with that of an imported sample:

	Vereeniging brick. *Per cent.*	Imported sample. *Per cent.*
Silica (free)	96·31	93·24
Silica (combined)	0·24	0·45
Silica (hydrated)	0·45	0·35
Alumina	2·25	3·76
Iron oxide	0·27	0·16
Lime	0·30	1·86
Magnesia	0·00	0·00
Undetermined	0·18	0·18

Magnesite Bricks are made at Vereeniging.

Pegmatite.—None has been found sufficiently pure for pottery manufacture.

Felspar.—All specimens examined have been ferruginous.

NOTES

Agricultural Legislation in Egypt.—A useful compendium of the laws now in force for the protection of crops and stock in Egypt has been published by the Egyptian Government under the title, *Législation Agricole et Vétérinaire* (Cairo: Government Press, 1920; price P.T. 10).

In the agricultural section of this publication the legislation leading up to the creation of a Ministry of Agriculture in 1913 is first given, and this is followed by the laws relating to the protection of cotton, prevention of the introduction of plant diseases from abroad, the insect pests and diseases of fruit trees, protection of birds useful to agriculture, destruction of locusts, and agricultural education.

The veterinary section begins with the decree of January 20, 1914, by which the veterinary service of the country and the veterinary school at Cairo are attached to the Ministry of Agriculture, and then gives the laws and regulations concerning precautions to be taken to prevent the spread of epizootic diseases among animals, as well as those relating to the slaughtering of animals for food and the sale of meat. The regulations and orders affecting the veterinary school are also given.

The section of this publication that will probably be of most general interest outside Egypt is that devoted to cotton, and the laws and ministerial orders relating to this crop are summarised below.

Transport of Unginned Cotton.—Law No. 16 of 1913, the object of which is to prevent the fraudulent admixture of cotton grown in Upper Egypt with Delta cottons in the course of ginning, prohibits all transport of unginned cotton between Lower and Upper Egypt in either direction. The precise line of demarcation between Lower and Upper Egypt, for the purposes of the law, is to be defined afresh for each year by an order of the Minister of Public Works published in the *Journal Officiel*, before July 1. The order (dated May 17, 1919) fixing the line of demarcation for 1919–20 is given, and a map at the beginning of the volume shows the boundary fixed for 1914–15.

Cotton Worm.—The object of Law No. 6 of 1913 is to prevent the propagation of the cotton worm by the growing of bersim, which is another food plant of this pest. The irrigation of bersim is prohibited after May 10, or such later date as may be fixed annually for certain

districts by the Minister of Public Works. Provision is also made for steps to be taken when cotton worms are found to be present in dangerous numbers on land planted with bersim. Law No. 11 of 1918 requires the immediate notification of the appearance on any land of the cotton worm or its eggs, and of all such other insect pests and diseases as may by decree of the Minister of Agriculture be declared harmful to cotton, and prescribes, in the case of the cotton worm and its eggs, the steps to be taken to destroy the pest.

Cotton Aphis (*Aphis gossypii*) *and Hibiscus mealy-bug* (*Dactylopius sp.*).—These are declared by ministerial orders dated October 5, 1918, and February 15, 1919, respectively, to be harmful to cotton, and to come under the provisions of Law No. 11 of 1918.

Boll Worm.—Law No. 17 of 1916, as modified by Laws Nos. 12 and 15 of 1917 and No. 19 of 1918, orders that before certain dates in each year (December 15, December 31, or January 15 according to district) the roots of cotton, hemp and bamia (*Hibiscus esculentus*) shall be plucked up, or cut down below the soil level in such a way that they cannot give rise to any fresh growth. All bolls remaining on cotton plants or scattered on the ground after the harvest must be removed or picked up and immediately destroyed by methods prescribed by order of the Minister of Agriculture; this must be done before such date as may be fixed annually by the Minister of Agriculture, and in any case before the trees are rooted up or cut down as prescribed above. The last provision may, however, be relaxed in cases where it is considered by the Minister of Agriculture that the removal and destruction of the bolls could be better effected after the plant has been plucked up or cut down.

Pink Boll Worm.—Measures for dealing with this pest are the subject of Law No. 29 of 1916. Between May 1 and August 1 of each year, cotton seed and unginned cotton may only be stored in warehouses (whether public or privately owned) which are authorised by the Ministry of Agriculture. This authorisation is only accorded to warehouses which can furnish such guarantees as the Ministry may require that no moths will be able to escape. All cotton ginneries must be provided with special apparatus, approved by the Ministry of Agriculture for treating the seed with a view to the destruction of the pink boll worm, and no seed must leave the ginnery without being so treated. The police and the agents of the Ministry of Agriculture are empowered to visit any warehouse or ginnery in order to see that these regula-

tions are being carried out, and penalties are imposed for their contravention. The conditions of application of the law are to be determined by the Minister of Agriculture, and an order under this provision, dated January 17, 1917, lays down certain conditions that must be complied with by a warehouse for storing cotton seed or unginned cotton, in order that it may be authorised by the Ministry. These are: (*a*) All windows, ventilators, chimneys and other openings (except doors) must be entirely covered with wire gauze or netting, having not less than ten meshes to the centimetre, or else completely closed. (*b*) Doors must close perfectly. The same order requires that the doors of all authorised warehouses be kept closed from sunset to sunrise between May 1 and August 1. The authorisation of any particular warehouse is only valid for the year for which it has been granted.

The Udi Colliery, Nigeria.—In 1903, at the suggestion of the Director of the Imperial Institute, a Mineral Survey was organised to examine the mineral resources of Southern Nigeria. For this purpose, two surveyors, selected by the Director of the Imperial Institute and trained in field geology and mining, visited Southern Nigeria each year, and carried out a definite scheme of exploratory work in selected areas. The samples collected by them were forwarded to the Imperial Institute for examination. The Survey lasted from 1903 to 1913, and nine summary reports relating thereto were published in the *Miscellaneous Series of Colonial Reports.*

One of the most important results obtained in the course of the Survey was the discovery of large deposits of lignite and coal. Up to date the lignite has not been worked, but a large and valuable coal-field, discovered by the surveyors, Messrs. A. E. Kitson and E. O. Thiele, in 1909, having the native villages Udi and Okwoga, at its southerly and northerly limits respectively, is being actively developed.

A description of this coal-field, which covers an area of 1,800 square miles, was given in this BULLETIN (1916, **14**, 369). Sir F. D. Lugard, in his *Report on the Amalgamation of Northern and Southern Nigeria, and Administration,* 1912–19, published this year, gives some information with regard to the later development at the Udi Colliery. The following notes are taken from that Report.

The coal outcrops on the side of a short range of hills, running north and south, which fall steeply to the general level of the country traversed by the railway.

The colliery is worked by an adit, the coal itself being won by the bord-and-pillar system. An inclined plane delivers the coal into railway trucks below. There is no lack of voluntary native labour, and natives are gradually being trained to replace Europeans; the present wage is fixed at 5*d*. per tub of 5 to 6 cwts. Owing to the friable nature of the overburden, an unusual quantity of pit-props is consumed. These are supplied from the mangrove forest surrounding Port Harcourt. The reserves of coal in the comparatively small area developed by the Government are estimated at 12,000,000 tons. The present output is over 500 tons a day with a maximum of 768 tons. The output for last year was estimated at 200,000 tons; this should leave a surplus, when Government requirements are satisfied, of 8,000 tons a month for sale to the public.

The electrification of the mine will be undertaken as soon as possible, and proper haulage engines and fans will be established.

The cost of the coal f.o.b. at Port Harcourt may be put at 28*s*. a ton, the cost to Government departments ex-wharf Lagos in 1918 being 56*s*. The value of the coal for steam-raising purposes is estimated at 80 per cent. of the best Welsh coal. The latter cost 105*s*. per ton at Lagos in 1916, and at that figure the relative price of Udi coal would be 84*s*.

The Chief Accountant of the Government has calculated that at present the working costs of a company (including directors' fees, etc.) would be 8*s*. 4*d*. a ton, and that, with a pit's mouth price of 10*s*., a dividend of 8 per cent. would accrue on the capital outlay, with 1*s*. royalty, or 12 per cent. with a royalty at 6*d*. The profits would be largely increased by a greater output and up-to-date machinery.

With regard to the value of the colliery, Sir F. D. Lugard writes:

"To the energetic development before the war of this coal-field, and the railway which serves it, Nigeria owes more than is easily calculable. Without it the Western Railway, which is earning £1,200,000 a year, could not have been kept running at full capacity, even at enormous expense, and the supply of oleaginous produce and of tin, so much needed in the United Kingdom, would have been greatly restricted, the exploitation of local timber would have been impeded, and the administrative machinery would have suffered the greatest inconvenience. Great as these direct advantages are, the indirect and per-

manent results are hardly less. A particularly turbulent tribe has been taught to seek labour for wages, and has earned not less than £34,000 in cash, with which to purchase imports, and improve its standard of living. The new railway has been able to pay its way, instead of being a burden on the depleted revenue ; a new outlet has been afforded for native skilled labour, with a new means of training it, and a coin currency has been promoted through a large and densely populated district."

The English China-clay Industry. An interesting series of articles on the china-clay industry of the West of England, by Henry F. Collins, A.R.S.M., appeared in the *Mining Magazine* (Nov. and Dec., 1919 ; Jan. and Feb., 1920), in which the older as well as the more modern methods of preparing china-clay for the market are admirably described. The articles are well illustrated by maps, section and views from photographs. The following notes are mainly based on these articles, and on *The Hensbarrow Granite District*, by J. H. Collins (1878), and *A Handbook to the Collections of Kaolin, China-clay and China-stone in the Museum of Practical Geology, Jermyn Street, London*, by J. Allen Howe (1914).

Strictly speaking kaolinite, which is a hydrated silicate of alumina and very similar in composition to serpentine (magnesium taking the place of aluminium), is the mineral which forms the basis of the china-clay of commerce. The names kaolin and china-clay are often used synonymously, but, to avoid confusion, it would be better to restrict the latter term to the prepared article. Kaolin is the result of the kaolinisation of granite, gneiss, pegmatite, porphyry and felspathic sandstone and quartzites. The quartz and mica remain unattacked, but the felspar undergoes a chemical change—for instance, potash felspar or orthoclase, which more readily undergoes decomposition than other felspars, loses the potash and part of the silica and oxygen, and combines with water, half of which replaces the potash removed. The kaolinisation was brought about by some acid, *e.g.* by carbonic acid, or possibly by hydrofluoric acid, and, in special instances, by sulphuric acid. The deep kaolin deposits of the West of England most probably owe their origin to hydrothermal action, or possibly to pneumatolysis.

In Cornwall the principal deposits of kaolin occur in the granite area north of St. Austell (Hensbarrow district). Other granite areas being worked are Dartmoor (south-eastern portion, north-west of Plymouth) ;

that to the north of Bodmin; the Tregoning Hill, north-west of Porthleven; and Land's End. Nothing has yet been proved in the Wendron area.

The completely kaolinised granite is called "china-clay rock" by Howe and Collins ("kaolin-rock" would be better), and is the "clay-ground" of the clay workers. It corresponds more or less to the *caillouteuse* of the French, and must not be confounded with china-stone, which is only a partially kaolinised granite, is much harder than kaolin-rock and can be used as a building-stone. China-stone corresponds more or less to the *petuntse* of the Chinese, which is a quartzose felspathic rock consisting largely of quartz. There are many varieties of china-stone. The Cornish variety is known as "Cornish stone," and is usually characterised by the presence of topaz and fluorspar, and the complete absence of tourmaline and biotite. After heating to 1,200° C., it solidifies to a pure white, opaque, vitreous mass resembling enamel ("frit"). It is sent to the Potteries (Staffordshire), and is used with china-clay, ball clays and flint, in the manufacture of English bone china, white stone-ware and granite-ware, and for forming an earthenware body; it also forms from 20 to 25 per cent. of porcelain glazes, but is unsuitable for hard porcelain.

The completely kaolinised granite, known in Cornwall as "clay-ground," and which is called "kaolin-rock" in these notes, is usually so soft that it can be cut out by a spade. On an average it contains from 20 to 25 per cent. of clay, the remainder—consisting of grains of quartz, particles of less decomposed granite, fragments of hard felspar and tourmaline, and mica—is known as "sand."

The decomposition has followed the leaders or veins of quartz and schorl (black tourmaline) which traverse the deposits, and the latter, in consequence, are dyke-shaped (single system of parallel veins) or basin-shaped (two systems which cross each other at a high angle). The kaolin-rock usually underlies slight depressions of the surface of the ground, known as "slad," or "slatt" to the older clay workers. When the clay deposit has been located, its approximate extent is ascertained by trial pits, sometimes supplemented by bore-holes. The over-burden, consisting of loose earth and gravel with granite boulders, may be from 3 to 60 ft. in thickness. This is removed by hand labour, if shallow, or by a steam navvy, if deep. The actual method of winning the deposit depends, largely, of course, on the configuration of the ground. If on a hill-side, the deposit is opened up by means of an adit, with grade sufficiently steep for the

stream of water to carry out the "sand" together with the clay, or, if this be impracticable, then only of sufficient grade to carry out the clay stream—the "sand" being raised from the pit by means of wagons running on an ordinary incline. If the driving of an adit is not feasible, then a shaft is sunk in the hard rock to a depth of from 60 to 240 ft., according to the local circumstances, a cross-drift is run in from the bottom of it to the central line of the deposit, and a rise is put up from the end to the surface. In the rise a box-pipe of rectangular section, from 4 to 9 in. in diameter, with large plug-holes down the side ("button-hole launder") is fixed—the use of which is explained later. The operation of breaking the clay-ground follows. A stream of water is conducted over the surface of the exposed clay ("stope"), where, aided by men with chisel-pointed picks ("dubbers") and two-pronged hoes, it soon cuts out a gully ("strake"). Into this the sides are broken down and the lumps disintegrated in order to keep the average load of clay carried by the stream as heavy and uniform as possible. To get rid of the coarse sand the current is allowed to pass into shallow sand-pits, with fronts built up of slats, which are filled and emptied alternately, the accumulated sand being shovelled into wagons, which are hoisted up the incline to the top of the pit and passed to the waste-heap, or "burrow." The clay-water, containing fine sand and mica, passes into the top hole of the vertical launder, the remainder being closed with plugs, down the rise and along the drift to the bottom of the shaft, whence it is pumped to the surface. As the level of the open pit is lowered, successively lower button-holes are reached and opened, and the upper part of the launder is sawn off stage by stage. Finally, when the full depth of the pit is reached, the launder no longer exists, and the clay-water, by lateral extension of the "strakes," flows directly into the drift.

When "fat" clay-ground is to be won, *i.e.* with a ratio of clay to sand of not less than 1 to 3, a method of hydraulicking is now used—water, under a pressure of from 50 to 100 lb. per square inch being discharged from a nozzle, from 1¼ to 1½ in. in diameter, at the bank. With new and shallow pits of similar clay, the clay-stream, carrying both sand and clay, is raised within the pit itself by means of centrifugal pumps. Two of these, right and left-hand respectively, are commonly mounted upon the same shaft, an electric motor being between them. One of the pumps is connected to the suction in the sump and delivers to the other, which forces the

stream to the surface, the total head being perhaps 60 or 80 ft. The pump delivers into large wooden boxes with hopper bottoms, in which the sand settles.

Arrived at the surface, the clay-water passes in a wide, shallow stream through a series of long, narrow wooden or masonry channels, arranged in parallel. In the first series (" drags "), the stream deposits only the fine sand, in the second and following series (" micas ") the clay-water runs more sluggishly and deposits the finest sand and flakes of mica. Movable wooden slats and traps, actuated by a lever, act as dams to control the depth and velocity of the parallel streams in each series of channels. By this means the proportion and fineness of the sediment deposited are controlled. At intervals the flow of clay-water is interrupted and the sediment is scoured from the micas and run into separate pits, whence, after passing a separate series of " drags," to get rid of the coarser particles, the resulting clay forms " mica-clay " or " mica," an inferior grade of clay. For the purpose of cleaning, each channel of the series is provided with a plug-hole opening into a launder running crossways underneath. The coarser part of the fine sand is often separated in one or more spitzkasten (pointed boxes) before it passes to the first series of " drags." To separate grass and other vegetable matter, fine wire-cloth screens are used at the head, and frequently at the tail, of the " micas."

The stream of purified clay-water from the micas is run through a wooden launder, or earthenware pipe, to the settling-pits, which are circular, lined with masonry, from 25 to 40 ft. in diameter, from 8 to 10 ft. deep, and often cement-lined. The pit slopes slightly towards a sluice-gate (" hatch "), which is fixed on the opposite side to the entrance of the clay-water. This is provided with plug-holes which are kept closed, except those near the top through which the clear water flows. The pits are filled intermittently until within about a foot of the top, when they are discharged by means of long-handled wooden rabbles (" shivers ") into rectangular storage tanks at a lower level. The storage tanks, made of stone and generally lined with cement, are from 100 to 180 ft. long, 40 to 60 ft. wide, and from 6 to 9 ft. deep. Each tank is provided with a wide door or hatchway leading to the kiln, and closed with slats of heavy planks. Further settlement takes place in these, and a little more water is drawn off by plug-holes. On the removal of the top slats of the hatch, some of the thick slurry nearest to it can be run into the drying-kiln (" dry ") ; the bulk is

loaded into wooden wagons or movable sections of tramway, which are run through the hatch on to a "traveller." The "dry" consists of the drying-kiln proper, or "pan," and, at a lower level, of a storage shed or linhay. The floor, or pan, is from 200 to 250 ft. long, 12 to 15 ft. wide, and is made of fire-clay tiles 12 × 18 in., 4½ to 5 in. thick at the furnace end, and from 2 to 2½ in. at the stack end. They rest on thin walls of fire-brick, 4½ in. wide, forming the flues, which are usually 14 in. wide, and 18 in. deep at the furnace end, and 9 in. deep at the stack end. There are usually three furnaces, each feeding three or four flues. The wet clay is spread on the floor 10 to 12 in. and 5 to 7 in. thick at the fire and stack ends respectively. The clay, when dry, shrinks in thickness to 9 and to 4½ in. respectively. At the hot end the clay dries in twenty-four hours; at the other end in from five to seven days. When half the clay is dry, it is scored part of the way through by a heavy sharp-edged hook, or "cutter." It is then raised by suitable means and placed in the linhay, or storage shed.

At most of the modern clay works the drying is effected close to the shipping port, the purified and thickened clay pulp being conveyed by stoneware drain-pipes with cement joints from 8 to 10 in. in diameter. The solid content is from 12 to 20 per cent., and the pipe is run only half-full, with a fall of 1 in 100. At the lower end of the pipe-line the stream runs into large rectangular tanks having a capacity of from 1,000 to 2,000 tons. For thickening the pulp, conical bottom-discharging settling-pits are used, from 30 to 40 ft. diameter at the top; their depth increases from 2½ ft. at the margin to 15 ft. at the centre, where a valve of the conical-plug type is fixed, discharging into a tunnel below.

Recent improvements consist in using Johnson filter-presses, which are filled by a pump working at 90 lb. pressure, by which means the water can be reduced to one-half. The presses take a charge equal to 30 cwt. of dry clay, which is turned out in cakes 1½ in. thick. The cakes are fed into a horizontal pug-mill, which turns out wire-cut blocks, 12 × 9 in. section and 10 in. long, weighing 80 lb. when dry. In the drying process, a great economy of fuel is effected through attending to the proper combustion of the fuel, and elimination of all excess draught of cold air through the furnace. The net result is a diminution of fuel consumption of from 30 to 50 per cent.

At some works aluminium sheets, ¼ in. thick, are substituted for 2 in. fire-tiles; with these the clay at

the far end can be dried in three instead of five or seven days. Better results are likely to be obtained by cutting the long kilns (300 to 350 ft.) into two, erecting short stacks in the centre, and furnaces at both ends.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the BULLETIN *a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India and the Tropics generally. It must be understood that the Imperial Institute accepts no responsibility for the opinions expressed in the papers and reports summarised.*

AGRICULTURE

FOODSTUFFS

Indian Famine Foods.—An account is given in *Agric. Journ. India* (1920, **15**, 40) of the following materials utilised in Ahmedabad in years of deficient rainfall, both for human consumption and for cattle feeding. (1) "Bid," the rhizomes of the sedge, *Scirpus kysoor*, Roxb. The ground containing the rhizomes is dug, the clods broken down with a hammer, and the rhizomes and the attached roots piled into a long ridged heap. The heap is covered with inflammable material and fired, in order to burn up the roots adhering to the rhizomes and facilitate the removal of the attached earth, which is effected by washing in water. The softened rhizome is broken up with a heavy stick and fed to cattle. When intended for human consumption the rhizomes are allowed to dry for some weeks in the clods, thereby developing a sweeter taste. They are then separated as described above, dried in the sun, and reduced to flour between stones. The dried rhizomes yield about 60 per cent. of flour, containing about 9 per cent. of proteins and 78 per cent. of digestible carbohydrates. (2) "Thek," rhizomes of the sedge, *Cyperus bulbosus*, Vahl. These are prepared in a similar manner to the rhizomes of *Scirpus kysoor*. They are treated more as a novelty, and cannot be kept long, as they rapidly decay. (3) Inflorescence of *Typha angustata*, Bory and Chamb., the pollen of which is rubbed off and used as a flour, known locally by the name of *poli* of *pan*. The flour is moistened with water, made into

cakes and roasted, furnishing sweet, yellow cakes quite palatable as a human food. (4) " Kanda," the tubers of *Nymphœa stellata*, Willd., a common water-lily of the district. These are roasted in ashes in the same way as potatoes, and consumed in this condition, or prepared by boiling in the manner usual with other vegetables. The fruit and seed of this plant are also used for human food, and known as " lampan " and " lampdi " respectively. The seeds are milled and the flour mixed with wheat or barley flour, and made into bread. The taste is unpleasant and the smell objectionable, but the bread is very light. The dried tubers of this plant contain about 15 per cent. of protein and the seeds about 11 per cent.

Coffee.—*Circular* No. 4, 1920, *Dep. Agric., Uganda*, contains an account of the work carried out to investigate the causes of the die-back disease of *Coffea arabica*, which has been responsible for much loss in the Protectorate since its appearance on a large scale about 1913. Inoculation experiments led to the conclusion that the prime cause of coffee die-back in cases where it occurs on a large scale was to be found in some other direction than that of the fungi found *in situ*, and that the chief cause is most likely physiological—in other words, that severe attacks of die-back disease only occur when the vitality of the trees has been reduced by some means or other. The history of Hemileia disease in Ceylon shows it to have been responsible in that country for a progressive loss of vigour which led to diminished yields, and the final abandonment of coffee cultivation. This disease made its appearance in Uganda in 1912, and attacked with great vigour trees of all ages, and the impaired vitality of the trees may perhaps be attributed more to this cause than to any other. In addition, many estates took two crops in one year from the trees at a critical period, a strain that the trees were unable to bear. Further, it is pointed out that set-backs due to attacks of scale insects, leaf-eating caterpillars, borers and thrips have caused serious harm. These factors are regarded as of primary, and the fungi as of secondary importance in large scale die-back; in small scale die-back, *Colletotrichum*, and probably also *Phoma*, should perhaps be considered as of primary importance. Preventive rather than remedial measures are recommended, and consist, briefly, in planting only the finest seedlings from the best obtainable seed; improved cultivation, including mulching and manuring; and prevention of over-bearing by the removal of a proportion of the young berries from

the branches. Light shade is essential because over-shading will increase the relative humidity, and induce stomatal opening and so aid infection.

Oils and Oil Seeds

Coconuts.—Two diseases of the coconut palm in Jamaica which are caused by fungi of the genus *Phytophthora* are described in the *West Indian Bulletin* (1920, **18**, 61). The existence of bud-rot, caused by *P. palmivora*, Butler, is indicated by the pale colour, bending over, browning and breaking down of the heart-leaf. Sometimes two or more of the youngest leaves lose colour and droop before the heart-leaf breaks down. More rarely one or more of the youngest leaves show rows of rounded spots running across the pinnæ, before signs of drooping appear. If the tree is allowed to stand after the heart-leaf dies, the young leaves next in order turn yellow, and the central column falls out, leaving a ring of fully expanded leaves which retain their colour frequently for many months; young nuts cease to develop and eventually fall, but those well grown may mature. The infection, which ultimately proves fatal to the tree, starts in spots on the younger leaf bases, and the fungus must penetrate several before it reaches the tender tissue of the bud. Nothing definite can be stated as to the means by which the infective matter is conveyed into the tops of the trees. During a hurricane the tops of diseased trees may be so opened out that infecting matter which is not accessible to breezes under normal conditions may be swept away and carried to other trees; this doubtless accounts in part for the great increase of disease after storms. The destruction of dead hearts by fire after cutting down the trees has been compulsory since 1911. A prophylactic treatment of non-diseased trees has been carried out at several large estates where disease was severe and fungicides applied to the hearts, but the results were inconclusive on the whole. The disease is mainly restricted to the eastern and north-eastern coastal lands with large unbroken areas of coconuts and a rainfall of about 90 to 120 in. In these districts trees ranging from two to three up to twenty years old are liable to attack. Disease is to a marked degree most prevalent on the flat lands, especially on fine silt soils. A period of heavy rains is always followed by an increase of disease, dead hearts beginning to show up from one to two months later.

The earliest symptom of leaf-stalk rot, caused by

Phytophthora parasitica, Dastur, is usually a yellowing and withering of the tip of one of the leaves between the central region of the crown and the outermost limbs. One or more adjoining leaves then become similarly affected, and finally most of the outer limbs break down. The progress of the disease is slow. The stalks of the affected leaves show dark brown, somewhat sunken spots from one to several inches in diameter on the upper and under surfaces ; the lowest spots are usually several inches above the union of petiole and stem. Long dark patches are also frequently present on the limbs, and gum may exude when the affected areas crack. The disease in Jamaica has been observed only on three neighbouring estates in a coastal district of high rainfall. Cases have occurred in trees from ten to fifteen years of age, but in greatest number on trees of five years beginning to bear. Attempts to stay the passage of the fungus from limb to limb by cutting out the affected leaves and spraying the exposed bases with Bordeaux mixture or smearing with Bordeaux paste have not been successful. More promising results have been obtained by packing banana or coconut trash round the affected limbs and firing it.

Attention was called in an earlier number of this BULLETIN (1919, **17**, 598) to a disease of coconuts in the West Indies caused by a nematode and known as " red ring " disease. At the Government Coconut Plot, Westerhall, Grenada, experiments have been carried out on coconut palms about seven years old, with a view to determining the method of infection of the disease (*West Indian Bulletin*, 1920, **18**, 73). The trees were inoculated with disease-infested material in the stem, the petioles and the leaf axis. Six out of the eight trees experimented with were found to be infected after sixty to seventy-four days. The two failures were trees in which infection was attempted on a basal leaf. The results of these experiments support the idea that infection occurs in the leaf-bases, and more recent observations in Trinidad suggest that this may frequently take place by way of the small cracks which develop in the fold made on the outside of the leaf-base by the bending outwards of the leaf as it matures. In many leaves examined there was a narrow streak of infested tissue connecting this point with well-developed infestations in the softer tissue further along the petiole.

Miscellaneous.—Experimental trials with the seeds of *Polygala butyracea* have been made in Saigon (*Les Matières*

grasses, 1920, p. 5542). It is suggested that the seeds should be sown in May or June at the rate of 12 to 15 kilos. per hectare, and manured with 4,000 kilos. of farm manure and the same quantity of cotton-seed cake per hectare. It will probably be found best to sow the seed at intervals of 20 cm. in lines 40 cm. apart. The field should be weeded on the appearance of the young plants, and hoed in July. The plant flowers in November, when it is 2 metres high, and the seed can be harvested early in January. The yield of seed in different experiments has varied from 409 to 578 kilos. per hectare (375 to 500 lb. per acre). The seeds, on pressing, gave a yield of 30·1 per cent. of a white fat with an agreeable taste and similar in appearance to lard. It is considered that this fat could be employed in the manufacture of margarine. These results conform with those obtained some years ago at the Imperial Institute in the case of the seeds of this plant received from Nigeria, where it is known as "cheyi" (this BULLETIN, 1913, **11**, 62).

The standard specifications for tung oil as drawn up by the American Society for Testing Materials are published in *Circular* No. 100, 1920, *Educational Bureau, Paint Manufacturers' Association, U.S.* According to this authority tung oil should conform to the following requirements: specific gravity at 15·5/15·5° C., 0·939—0·943; acid value, 6 (max.); saponification value, 190—195; unsaponifiable matter, 0·75 per cent. (max.); refractive index at 25° C., 1·515—1·520; iodine value (Hubl. 18 hrs.), 165 per cent. (min.); heating test, 12 mins. (max.). The circular also contains details of the methods of analysis recommended.

Circular No. 86, 1920, of the same Association gives the results of the preliminary examination of the oil obtained from the yellow tail fish (*Seriola dorsalis*), which is abundant on the Southern and Lower California coast. The unfiltered oil gave the following figures: iodine value, 177 per cent.; saponification value, 190; specific gravity, 0·9322. This oil contains a large quantity of "stearine," which can be removed by filtration, giving a very clear pale oil. Drying trials with yellow tail fish oil showed that it could be used successfully in admixture with linseed oil for paints.

It is suggested in *Les Matières grasses* (1920, p. 5312) that the waste products from the rice mills of Italy should be pressed so as to obtain the oil that they contain. It is stated that more than 30,000 quintals (nearly 3,000 tons) of this oil could be obtained from the 6,000,000 quintals of rice that are treated there annually. The resulting

bran would have the advantage of keeping longer than usual, as it would be freer from the oil that tends to turn rancid and thereby damages the bran as a feeding-stuff for cattle. It is considered that the oil could be employed for soap-manufacture and possibly for margarine.

RUBBER

Hevea

Diseases.—In an article on "The Plantation Industry and its Critics" (*Agric. Bulletin, F.M.S.*, 1919, **7**, 221), W. N. C. Belgrave answers some of the criticisms which have been made recently in connection with the scientific side of rubber planting, more particularly those relating to disease. It is pointed out that the scientific staff, Government and private, sanctioned for the Malay Peninsula in 1919, was at least equal to that thought necessary for the future by Dr. Butler and others, which indicates that neither the Government nor the rubber planting industry have shown any neglect of scientific work. Professor Baker, in an article entitled "Hevea *versus* Fungi" in *The Gardens' Bulletin, Straits Settlements* (1919, **2**, 109), of which a short abstract appeared in this BULLETIN (1919, **17**, 435), drew attention to the importance of research in connection with fungi on Hevea and made a number of statements which are called in question by Belgrave. Baker stated that "planters and Government administrators cannot be expected to become fully alive to the problems involved and the necessities of the case until staggering losses have been suffered, or until wholesale infection has occurred"; but Belgrave points out that there have so far been no "staggering losses" or "wholesale infection" in Malaya, and yet both Government and industry have taken steps to deal with disease, by the appointment altogether of nine mycologists, mostly for work on rubber. There are at present no signs that, as Baker contends, "fungi will constitute the limiting factor" so far as rubber production is concerned, but there may be other limiting factors, such as soil-wash, to which he makes no reference. Baker strongly (and rightly) recommends plant sanitation, but Belgrave takes exception to the implication that sanitation is non-existent and has not previously been recommended. He mentions that the Agricultural Department of the Federated Malay States have advocated plant sanitation for years past, and measures of sanitation are vigorously applied on the

majority of estates. It is further stated that work on the supposed saprophytes of Hevea, to which Baker calls attention, was being conducted by the Department, until it was interrupted by war exigencies. Belgrave concludes by saying that "the planting industry as a whole is fully alive to the necessity for research work and to the dangers of disease. . . . Epidemics may occur, . . . but it will not be for want of forethought or attention on the part of those responsible for the well-being of the industry."

Coagulants.—Experiments carried out in Java with various coagulants are recorded in *Arch. voor de Rubbercultuur, Ned. Indië* (1920, **4**, 163). (i) *Sulphuric acid.* Small quantities used for coagulation did not give large deviations in the properties of the rubber, but with somewhat large amounts the rate of cure and the viscosity of the rubber decreased markedly, and much more rapidly than when corresponding amounts of acetic acid are used. A practical drawback is that sulphuric acid strongly corrodes the iron of the rolls and other material of the factory with which it comes into contact. The properties of the raw or vulcanised product on keeping changed in exactly the same way as after acetic acid coagulation. (ii) *Alum.* Coagulation proceeded best with undiluted latex, in which 3 to 4 grams of alum per litre was sufficient, whilst 8 to 12 grams gave rapid coagulation. Small quantities of alum caused a marked decrease in the rate of cure and in the viscosity, whilst larger amounts gave an abnormally slow curing rubber with a low viscosity. (iii) *Acetic acid*, prepared locally by wood distillation, had the drawback that the tarry substances were difficult to remove completely, so that crêpe could not be prepared with it, and even the colour of the sheet became too dark, so that eventually the market value decreased so much as to more than neutralise the saving effected by the use of such acetic acid. Acetic acid, prepared by fermentation of alcohol, was cheap, and proved a good coagulant, but its preparation required considerable care and supervision. Commercial acetic acid, if cheap enough, is therefore to be preferred. The crude acids gave rubber of practically the same mechanical properties as that obtained by the use of ordinary commercial acid. (iv) *Fermented coconut water.* Coconut water, on fermentation, gave an acid liquid which proved satisfactory as a coagulant, giving rubber of exactly the same properties as that coagulated by commercial acetic acid, and just as uniform over long periods. Transport of the coconut

water, however, would be expensive, and it can only be used, therefore, on estates growing both rubber and coconuts. (v) *Acid coffee juice, i.e.* the acid juice obtained when the fresh red coffee berries are left to ferment for some days in water. The dark red colour of this coagulant renders it unsuitable for the preparation of crêpe, and in the case of sheet rubber the tint was darker than usual. The properties of the rubber from some experiments seemed to be injured somewhat, and, as this coagulant would only be available during the few months of the coffee harvest, it was not considered likely to be of any practical importance. (vi) *Acid water from a crater-lake.* This water, from the lake of the volcano Idjen, in Java, had a strong coagulating power, but proved injurious to the properties of the rubber. (vii) *Alcohol.* Coagulation by alcohol was found to leave the rate of cure unchanged, whilst the slope was always found higher and the viscosity mostly lower, as compared with results obtained with acetic acid as the coagulant. The tensile strength was either unchanged or somewhat less, and the ash content higher. The cost of this coagulant, even when using duty-free denatured spirit, was ten times higher than that of acetic acid, and is therefore only of interest for trial coagulations and experimental purposes when a rapid and complete coagulation is required. (viii) *Formic acid* proved to be irregular in composition, possibly on account of traces of formaldehyde, and gave irregular results, notably a marked decrease in the rate of cure in some cases. (ix) *Lactic acid* behaved similarly to acetic acid, except for a small decrease in the rate of cure; but the acid is too expensive to be of practical interest.

The Influence of Heavy Tapping on the Chemical Composition of the Latex.—The results of an investigation to determine the composition of the latex at various intervals during heavy tapping are described in *Arch. voor Rubbercultuur, Ned. Indië* (1920, **4**, 27). In the case of a tree with a circular cut down to the wood it was found that (1) the proportion of resinous matter to rubber in the latex remained constant; (2) the concentration of organic substances in the serum remained constant during the first fortnight, but subsequently decreased; (3) the percentage of nitrogenous substances in the latex remained unaltered during the first few days, subsequently decreasing to one-half; and (4) the concentration of the inorganic matter in the serum remained practically constant.

Fibres

Flax Substitutes.—In this Bulletin (1919, **17**, 422) reference was made to the work of the Empire Flax Growing Committee and a summary was given of its Report on the " General Situation and Immediate Prospects of Supply in April 1919." The Committee has now issued a further Report (Cmd. 762, 1920) on " Substitutes for Flax as at 27th April 1920." This Report deals with the question of the extent to which other fibres can be used to supplement the flax supply or serve as substitutes for flax, and is briefly summarised below.

Jute is already being used to some extent in the coarser end of the Scottish flax trade, but is unsuitable for the finer departments of this trade, or for the Belfast wet spinning trade.

Ramie could doubtless be used as a flax substitute to a much greater degree than is at present the case, but objection has been raised to its lack of elasticity and the tendency of ramie fabrics to crack when folded.

The better grades of Italian hemp could probably be used more largely in the linen trade for coarse and medium counts. It would be necessary, however, for spinners to buy hand-dressed, or what may be termed half-dressed, hemps and treat them by all the processes, preliminary to spinning, to which raw flax is subjected. Spanish hemp is inferior to Italian hemp, but Hungarian, China, American and Russian hemp (if obtainable) could be employed to some extent.

Nettle fibre has been used in Germany for the manufacture of textiles, but it may be assumed that it did not meet with much success. It would probably be no easier to cultivate than flax, and the Committee express the opinion that it would be better to extend flax cultivation than to attempt to develop the production of a new fibre which does not possess any marked advantages.

" Tucum " fibre is mentioned, but the quantity available is not known, and it cannot at present be regarded as a practical substitute for flax.

There are also other fibres which might be used to a limited extent.

The Committee reach the general conclusion that, although there are a number of fibres which can be employed in certain directions as flax substitutes when flax is scarce or when high prices are ruling, none of them is capable of satisfactorily replacing flax for the manufacture of fine linens, damasks and similar materials. The present difficulties in the linen trade due to the shortage

of flax can only be solved by the extension of flax cultivation.

Paper-making Materials.—An article has been contributed to *Nature* (1920, **105**, 599) by A. H. Unwin, late Senior Conservator of Forests, Nigeria, on the suitability of certain soft-woods of British West Africa for the manufacture of pulp or paper.

Baobab (*Adansonia digitata*) has been suggested as a useful tree for this purpose, but it is doubtful whether its exploitation would be remunerative, as it is usually found at considerable distances from the navigable waterways, and only in scattered quantities. The kapok tree (*Eriodendron anfractuosum*) is regarded as more promising, as it is easily produced, grows rapidly and yields a soft wood. The wood of *Bombax buonopozense* may also prove useful.

The African maples (*Triplochiton Johnsonii* and *T. nigericum*) may prove even more suitable, as they occur abundantly, can be easily propagated, are of rapid growth, and have long-fibred wood. On average soils these trees reach pulp-wood size within ten years, and sometimes even in seven years.

Certain species of *Sterculia*, viz. *S. Barteri*, *S. tomentosa*, *S. rhinopetala* and *S. tragacantha* might perhaps prove serviceable. Other trees which are worth consideration are *Albizzia* spp., *Terminalia superba*, *Alstonia congensis*, *Ricinodendron Heudelotii*, *Pycnanthus Kombo* and *Musanga Smithii*.

Bamboo does not occur in sufficient quantities at present, but the area of its distribution is gradually extending.

It is suggested that, in view of the present shortage of paper-pulp, efforts should be made as soon as possible to utilise these West African woods, and it is considered probable that pulp could be produced from them at a sufficiently low cost to enable it to compete with the wood-pulps now on the market.

Cotton

Pink Boll-worm.—An account of the present position of the activity of the pink boll-worm (*Pectinophora gossypiella* = *Gelechia gossypiella*) in the United States and of the efforts which are being made to restrict the area of infestation is given in *Service and Regulatory Announcements* (*Fed. Hort. Bd.* 67), *U.S. Dept. Agric.*, issued June 11, 1920.

The situation has been recently rendered more serious by the spread of the pink boll-worm over a considerable area of South-Western Louisiana and by the failure of the Texas authorities to prohibit cotton-growing in certain zones, and particularly in the Trinity Bay district, on the discovery of the fact that this area had been widely reinfested.

The presence of the pink boll-worm in Louisiana was discovered in February 1920. It is supposed that it was introduced into Cameron Parish in cotton seed obtained from Beaumont, Texas, in 1917, and has since spread to certain other parishes. It is possible that wider infestation in Louisiana and also in Texas may take place owing to large quantities of seed from these parishes having been distributed during the last three years to various towns in Louisiana and Texas. All these districts are being kept under regulation and thorough inspection, and immediately after the discovery of the infestation in South-Western Louisiana cotton cultivation was strictly prohibited in the parishes affected. The Louisiana Division of the American Cotton Association have applied to all the members of the Louisiana General Assembly for support in obtaining legislation for fighting the pest and for compensating farmers who are prevented from planting on the infested areas.

In Texas a vigorous campaign against the pink boll-worm was carried on in 1917–18 (compare this BULLETIN, 1918, **16**, 263) and at the end of 1918 there was every reason to ancitipate its early successful completion. Unfortunately, however, at the end of that season the planters in the Trinity Bay district demanded permission to grow cotton in 1919 under restriction, as the pest appeared to have been eliminated. The experts of the Department of Agriculture were strongly opposed to this plan, but ultimately the cultivation of cotton under restriction was allowed on condition that, if the boll-worm should reappear in the district, the State authorities would immediately establish a zone for all infested areas in which cotton planting would be prohibited, and would maintain it as long as might be necessary to eradicate the pest completely. This resumption of cotton-growing has resulted in the reappearance of the insect at various points over the whole area formerly infested, and its extension into new territories. Early in 1920 the situation became very serious owing to the failure of the Texas State to carry out the conditions and programme of control agreed upon. This was due to the strong opposition of planters in infested districts to the establishment of non-

cotton zones and to the apparent unwillingness of the authorities to take the drastic action which the situation required.

The reappearance of the pink boll-worm in Texas, and its discovery in Louisiana, present a most serious situation, and, unless the necessary action can be promptly and vigorously undertaken, the results of the earlier efforts to exterminate the pest in Texas will be lost, and the pest may become a permanent and serious obstacle to cotton production in the United States. It is recommended that non-cotton zones should be immediately declared for the infested areas in Texas, necessitating the ploughing up of fields already planted, and the cessation of planting in such areas, and that steps should be taken to assure planters that the losses thus incurred will be reimbursed by the State.

A valuable monograph on "The Pink Boll Worm (*Gelechia gossypiella*, Saunders) in Egypt in 1916–17," by H. A. Ballou, M.Sc., has recently been issued by the Ministry of Agriculture, Egypt (Cairo: Government Press, 1920). A full account is given of the origin and present distribution of the pest, and of its life-history, habits and natural enemies. The nature of the damage caused by the insect is discussed, and the amount of the reduction of the Egyptian crop due to its ravages is estimated. The efforts made in Egypt to control the pest, and the legislation enacted in this connection are recorded, and suggestions and recommendations are made for combating the pest in the future. A bibliography of the subject is appended, and the monograph is illustrated by sixteen excellent plates.

St. Vincent.—The progress of the cotton industry of St. Vincent is recorded in the *Rep. Agric. Dept., St. Vincent*, 1918–19. The meteorological conditions during that year were favourable in St. Vincent, but in the Grenadines the cotton suffered owing to prevalence of dry weather from December until the end of the season. The area planted with Sea Island cotton amounted to 6,030 acres, as compared with 4,710 acres in the previous year, the increase being due to the high prices ruling for the crop. About 40 per cent. of this area was planted by small growers, and the remainder by estate owners. The total yield of Sea Island cotton was 437,273 lb., or 95·4 lb. per acre. The average yield of this cotton in the Grenadines was less than 60 lb. per acre, whilst in St. Vincent it exceeded 100 lb. per acre. The prices realised for the 1918–19 crop were as follows: Ordinary, 36*d.* per lb.;

Good Ordinary, 40*d.* per lb.; and Superfine, 50*d.* to 55*d.* per lb. In the Southern Grenadines the area devoted to Marie Galante cotton was 1,446 acres.

A study of the conditions of the Sea Island cotton crop over a number of years has shown that the low average yield has been due to (1) adverse climatic conditions, causing shedding of the flower-buds and bolls, and the spread of diseases, (2) damage by pests and diseases not due to unfavourable weather, and (3) low fertility of the cotton lands. The last of these is the chief cause of the smallness of the crops at the present time, and it is pointed out that greater care is needed in the management of the soil, including the more extensive and intelligent use of manures, and also in connection with such matters as the rotation of crops and other means of soil restoration. It is considered that if the agricultural methods are improved and the work on the control of pests and diseases is continued, the cotton industry can be placed in a better position than it has ever yet attained. The efforts to reduce the attacks of the cotton stainer (*Dysdercus delauneyi*) have been carried on without intermission and an account of this work is given in the *Report*. The control of this pest has led to a reduction of the amount of stained cotton in the crop from over 25 per cent. in the 1916–17 season to about 14 per cent. in 1918–19. As stained cotton is worth only about half as much as white cotton, it is evident that the pecuniary advantage accruing to the industry is considerable.

In the *West Indian Bulletin* (1920, **18**, 20), an account is given by S. C. Harland, D.Sc., Assistant for Cotton Research in the Imperial Department of Agriculture for the West Indies, of "Manurial Experiments with Sea Island Cotton in St. Vincent in 1918–19, with Some Notes on the Control of Certain Diseases by Spraying."

The results of the manurial trials in 1918–19 confirmed those obtained in previous years (1912–18). A summary is given of the conclusions derived from the whole seven years' work which emphasises the following points. After cotton has been grown on the same land for several years in succession, as is the general custom in St. Vincent, the crop responds markedly to applications of both artificial and organic manures. The size of the crop is limited by the supply of potash in the soil, and it is evident that the lack of nitrogen in the soil is already becoming serious. The exhaustion of the soil in potash is obvious from the appearance on most of the cultivated lands of the "rust" or "red-leaf" disease. Most of the

cotton lands of St. Vincent have been largely depleted of potash and organic matter, and will soon cease to yield remunerative crops, and it is therefore necessary that potash manures should be imported. The application of phosphate manure is not advisable, as the use of potash and phosphate together is less beneficial than potash alone. Cotton-seed meal cannot be economically used by itself as a manure for Sea Island cotton, but should be supplemented with applications of potash and pen manure. Manurial treatment does not affect the time of the maturing of the crop. Differences in manurial treatment cause no notable difference in the proportion of bolls to flowers. There is great uniformity in St. Vincent in the time at which flowering and bolling begin, reach their maximum and finish. The bulk of the first crop is picked from the twenty-first to the twenty-fourth week after sowing.

With regard to the spraying trials, attention has been devoted to the effect of Burgundy mixture on (1) the disease due to *Bacterium malvacearum*, which is known by the various names of " angular spot," " black arm," and " external boll disease," and (2) to the " soft rot " disease due to *Phytophthora* sp. In the case of the former disease, the spraying prevents the " angular spot " aspect of the leaves, but is apparently ineffectual in preventing infection of the bolls, and it is therefore concluded that the treatment is useless as a measure of control for the " external boll disease." Further experiments are needed before any definite conclusion can be drawn as to the effects of the spraying on the " soft rot " disease.

South America.—An interesting account of " Cotton Growing in South America " is given by G. McC. McBride in the *Geographical Review* (1920, **9**, 35). The present position of the industry is described and the possibilities of increased production are discussed.

In Peru there are at present about 140,000 acres devoted to the crop and the area is continually being extended. The greatest possibilities of expansion occur in the Chira and Pisco districts, where an ample supply of water is available. The climatic conditions of the Peruvian coast are regarded as ideal for cotton cultivation, and it is considered that, if modern systems of irrigation were introduced, and the labour shortage overcome with the assistance of agricultural machinery, the production could be easily increased to several times the present amount.

In Brazil the production of cotton in 1917–18 was estimated to be about 400,000 bales. The pink boll-worm has caused considerable damage to the crop, and measures

to control the pest are being introduced by the State and Federal Governments. The possibilities of largely increased production are restricted by the deficiency of the labour supply and the lack of adequate transport facilities. In recent years the industry has been encouraged by the official Servico do Algodão, which is now under the direction of an American expert (see below).

In Argentina the northern part of the country and the adjoining areas of Bolivia and Paraguay possess enormous areas suitable for cotton-growing, but, just as in the cases of Peru and Brazil, the labour and transport problems render an extensive industry impracticable at present. According to the Argentine Department of Agriculture, the area planted with cotton during the 1918–19 season amounted to 32,680 acres, distributed as follows: Corrientes, 927 acres; Chaco and Formosa, 31,061 acres; La Rioja, Jujuy, Misiones, etc., 692 acres. Central and Southern Argentina are subject to sudden and extreme fluctuations of temperature, and are therefore unsuitable for cotton growing.

Reference is also made to the possibilities afforded by Venezuela and Colombia. Ecuador, Chile and Uruguay are not regarded as promising fields for extensive cotton production.

It is stated in the *Review of Applied Entomology* (1920, ser. A, **8**, 59) that, according to J. F. de Lima Mindello (*A Lavoura, Rio de Janeiro*, 1918, **22**, 664), in 1917 the cotton crop in the Brazilian State of Parahyba was reduced by 80 per cent. owing to attack by the pink bollworm.

In the *Board of Trade Journal* (1920, **104**, 774), reference is made to a decree establishing the Servico do Algodão for the extension and improvement of cotton growing in Brazil. This organisation comprises a superintending administration, experiment stations in the various cotton growing regions, and district delegations.

The special functions of the Servico do Algodão are to study the climate, soil, and geographical distribution of the various species of cotton in Brazil; to undertake experiments on the selection and hybridisation of cotton; to determine the typical characteristics of the best Brazilian species and to introduce exotic seed for acclimatisation experiments; to study the rotation of crops in relation to cotton; to select and produce on a large scale seed of the superior varieties for free distribution; to provide practical instruction for cultivators; to supply agricultural machinery and implements, insecticides, manures, etc., at cost price; to furnish information

regarding markets; to keep the Biological Institute of Agricultural Defence informed of any outbreak of pests, and the effects of measures of control which may be taken; to promote the installation of efficient cotton mills in the producing States; to organise standard commercial classification of cotton, and to send samples to national and foreign institutions interested.

ECONOMIC MINERALS

Iron Ore.—*Western Australia.*—Mr. A. Montgomery, the State Mining Engineer, has recently examined the iron ore deposits of Yampi Sound, on the north-west coast of Western Australia (*Report on the Iron Ore Deposits of Yampi Sound*, Western Australia Department of Mines, Perth, 1920).

The deposits are on Koolan and Cockatoo Islands, between which is Yampi Sound, an outlying portion of King's Sound. Yampi Sound is described as a very spacious, land-locked, deep-water harbour, which the largest ships can enter and leave at any time of the tide, and with deep water close to the shores. On both islands the iron deposits are in the form of huge beds of dense solid steel-grey crystalline hæmatite of "micaceous" structure, interbedded with quartzites and clay slates. The formation is provisionally referred to the W. A. Nullagine Series of the Cambrian System. The iron-ore beds are of sedimentary origin, and can be followed for long distances, striking E.S.E. to W.N.W., and dipping S.S.W. 50° to 55°. Here and there they follow the folding of the containing strata, and have the usual dip reversed or at low angles.

The iron beds of Koolan Island may be identical with those of Cockatoo Island; on both islands there are two main (northern and southern) groups of beds, both of which contain enormous quantities of ore, but the southern group is the more important one for the moment, as the iron beds have been uncovered over large areas by the erosion of the overlying strata. This is most complete on the southern side of Cockatoo Island, where, for about 110 chains in length, there is a steep cliff of iron ore, dipping 55°, the top of it being 300 feet above high-water mark. Actual measurements indicate a thickness of 130 ft., and preliminary estimates give 13,850,000 tons of ore in these beds at Cockatoo Island above high-water mark.

The Koolan Island southern ore-body has only been partially stripped of the country-rock forming the roof

The outcrop rises in one place to a height of 600 ft. above high-water mark, and is traceable for about 300 chains in length. Measurements taken at two points indicate a thickness of 100 ft. Towards the east end the bed is caught in a plication of the enclosing strata, and is so twisted that it dips northerly, and, in the easternmost bluff, the ore lies almost horizontal. The estimate is 68,850,000 tons of ore, a very large portion of which can be obtained without the removal of any overburden.

The outcrop of two northern ore-beds on Koolan Island can be traced for about 50 chains, but the thickness of ore is not at present measurable. A very large quantity of ore could be taken from these outcrops without removal of overburden, but, although there is a good deal of first-class ore, a large proportion is full of siliceous pebbles, forming a coarse conglomerate. There are probably not less than 7,700,000 tons of ore in the northern ore-bodies.

Three parallel beds form the northern group of ore-beds on Cockatoo Island, which measure 4 ft. 6 in., 6 ft., and 56 ft. across, dipping S.S.W. 55°, of apparently fairly good, but somewhat siliceous ore, and, going north to the bay on the north side of the island at this point, four others of from 4 to 6 ft. in thickness were crossed in about 100 yards, but too siliceous and poor to be taken into account at present as ore. The large bed could be quarried—the outcrop extends for about 100 chains. An estimate of 6,900,000 tons of ore seems reasonable for this ore-body.

The above estimates give a grand total of 97,300,000 tons of ore available above high-water mark.

About 10 chains from the Fantome trigonometrical station, in an easterly direction along the outcrop, there is a small plateau, at an elevation of 470 ft., some 5 or more chains in length and breadth, composed of water-worn pebbles of hæmatite cemented together into a conglomerate by brown oxide of iron. The conglomerate is almost entirely composed of gravel and boulders of good hæmatite ore. It would be easy to mine the conglomerate, and to recover from it at once a large tonnage of good class boulders of ore, and the balance could probably be washed clean enough for export by a simple sluicing treatment, using sea-water. A "grab" sample of the alluvial ironstone gave 60·91 per cent. of iron (metallic); 0·01 per cent. of sulphur, 0·050 per cent. of phosphorus and 2·64 per cent. of titanium dioxide.

Hundreds of thousands of tons of hæmatite have been broken away and buried under the water of the Sound. The Cockatoo Island deposit runs under the sea bottom

at both ends of the present cliff, and most probably more ore has gone into the Sound from the parts of the ore bed and the fallen away parts of the visible cliffs than is now remaining. Similarly, in Koolan Island, the ore bed runs into the sea at both ends, and has been breached as well at several inlets. It is very probable that a vast amount of ore could be recovered from the shallower water near these points by dredging. At a certain distance from the foot of the big cliffs the boulders should not be too coarse for dredging. In the shallow inlets, and on the shelves below the iron cliffs, there seems quite a good prospect of being able to recover a very large amount of ore.

The amount of ore obtainable by mining must be enormously greater than the estimate given. So far as is known at present, the beds probably extend for at least 13 miles in length, though parts of them are under the sea, and the extension at right angles to their length is quite unknown. Probably the ore could be found by boring on the mainland on the south side of Yampi Sound. The dip of 55°, seen in the cliffs, will probably flatten rapidly as the ore is followed downwards, as the enclosing formation appears to be, on the whole, somewhat flat-lying, though locally much bent and folded. It is probable that the ore-beds would not be too deep on the mainland side of Yampi Sound to be reached by boring and mining.

Analyses of the ore from the main bed on Koolan Island gave the following percentages: iron, 64·91 to 66·48; sulphur, 0·01 to 0·07; phosphorus, 0·009 to 0·062; silica, 4·16 to 7·06. The Cockatoo Island percentages were as follows: iron, 68·14; sulphur and phosphorus, nil; silica, 1·88. A sample of the north bed gave: iron, 51·7; sulphur, 0·05; phosphorus, 0·01; silica, 25·55.

The samples taken were of the nature of "grab" samples. Close sampling of such enormous ore-bodies would necessarily entail a great deal of time and labour being spent on them.

The analyses show that the ore is mostly of high grade, and free from deleterious impurities. In all but one analysis quoted, the phosphorus is below the limits of 0·05 per cent. allowable for acid open-hearth treatment, or 0·10 per cent. allowable for acid Bessemer ores.

The deposits can be easily worked by open quarrying —the ore being cut up into blocks by natural joints will greatly facilitate this—and it could be brought down by heavy blast with large charges of explosives placed in prepared chambers or tunnels. Many thousand tons of

ore would be sent to the foot of the cliffs by this means, ready for loading on to vessels. Steam shovels or electrically driven "grabs" will probably be most suitable for lifting the broken-down ore from the floor of the quarries, or some conveyer system may be preferable at some points.

Mr. Montgomery thus concludes his report: "The Yampi Sound proposition exhibits a combination of natural advantages to which I have heard of no equal anywhere in the world. The deposits are of great size, excellent quality, admirably placed for cheap ore-breaking, and situated alongside deep water on a natural harbour of the very best description. Its principal disadvantage is its distance from the world's iron markets, but there appears to be very good reason for believing that arrangements will be possible whereby rates of freight will be obtained low enough to allow the ore to be sold profitably for the producers."

According to the *Mining Magazine* (1920, **22**, 137), an option on the property has been secured by the Queensland Government, presumably in connection with its national scheme for iron smelting. This scheme is centred on the Mount Biggender magnetite deposits. Probably it is considered desirable to have hæmatite ores to treat concurrently.

Newfoundland.—During 1919 an important work connected with the development and future working of the well-known hæmatite deposits of Bell Island, Newfoundland, was brought to a successful conclusion. This undertaking is described by Mr. R. E. Chambers, the engineer in charge, in *The Canadian Mining Journal* of March 29, 1920. The work was commenced in 1913, and, although hindered by labour shortage due to the war, was continuously pursued to completion. It consisted in driving a pair of slopes (inclined galleries or drifts) from a point on the north-west shore of Bell Island for a distance of two miles under Conception Bay, and thus opening up an extensive submarine area. The hæmatite beds have been exposed by denudation in the north-west of the island, in two principal seams, the upper of which outcrops 230 yards, and the lower about 600 yards from the shore, dipping slightly to the north-west under the bay. Longitudinally these outcrops extend for about three miles along the coast. The ownership of these seams has been acquired by the Nova Scotia Steel and Coal Company and the Dominion Iron and Steel Company, both of which have been energetically mining and exporting ore for many years. It was early recognised that

the ore on the island itself, while representing some millions of tons, is small in quantity compared with that which is obtainable by following the seams dipping under the bay. Large submarine areas were therefore acquired by both the above companies, and in 1905 slopes or inclined drifts were started to develop them. The Dominion Iron and Steel Company, possessing the area next the shore, required only short slopes, but the Nova Scotia Steel and Coal Company's slopes, having to pass through the other company's property to reach their submarine area, required about a mile of slopes. By a mutual arrangement, the latter had to be surrendered to the Dominion Iron and Steel Company at the end of 1918, the Nova Scotia Steel and Coal Company having to provide independent slopes for their own requirements. It is this latter work which Mr. Chambers describes. Two parallel slopes each two miles long, and connected by a number of crosscuts, with a cross-section inside timbers of 15 ft. by 10 ft., have been driven at a descending grade of 13 per cent. From these slopes cross-drifts or headings are put out laterally, and the ore seams are worked from these by the pillar-and-roof method. The production of ore through these slopes is at present about 1,200 tons per day, but it is said that this quantity is capable of being greatly increased. The hoisting is carried out by electric motors, and ventilation is effected by means of a Sturtevant fan.

Contrary to expectation, the quantity of water entering the workings, while considerable, is not excessive, and is easily kept under by a few pumps of moderate capacity. The ore is trammed in cars of 30 cubic ft. capacity, which are made up into trains of five or six cars. It is conveyed into large receiving-bins, from which it can be loaded directly into vessels by means of chain-and-bucket conveyers.

The completion of the new slopes has served further to prove the very large extent of these hæmatite deposits and to open up immense quantities of ore, said to be sufficient not only for all future requirements of the Nova Scotia Steel and Coal Company on the existing scale of working, but for providing an output on a far larger scale for many years to come.

Sodium Sulphate.—A large deposit of sodium sulphate has recently been located in the Blue Mountains, Southern Saskatchewan, near the Lacombe-Kerrobert branch of the Canadian National Railroad. It is in the form of a lake bed, 4 miles long, and from 200 to 900 yards wide,

and is apparently somewhat similar in shape to Muskiki Lake (*Canadian Chemical Journal*, 1920, **14**, 143). The deposit is 2 ft. deep at the edge and 11 ft. at the centre. A pit dug in the middle of the deposit disclosed a spring which flowed in, carrying a heavy solution of sodium sulphate. An analysis of the salt, made by an official of the Ministry of Agriculture, Manitoba, yielded 98·5 per cent. of anhydrous sodium sulphate; water, 0·3; chlorine, trace; matter insoluble in water, 1·1. This is a very pure sample of dehydrated mirabilite or glauber salt. The deposit has been estimated to contain 2,000,000 tons (*Oil Paint and Drug Reports*, 1920, **97**, No. 12, p. 63; No. 17, p. 27). Another estimate gives 6,000,000 tons. Limestone occurs in the district, and the deposit is thus a promising one for the possible manufacture of sodium carbonate (*Journ. Indust. and Eng. Chem.*, 1920, **12**, 93).

NOTICES OF RECENT LITERATURE

THE KALAHARI, OR THIRSTLAND REDEMPTION. By E. H. L. Schwarz. Pp. vi + 163, with numerous plates, maps and figures. Demy 8vo. (Cape Town: T. Maskew Miller; Oxford: B. H. Blackwell.) Price 8*s*. 6*d*. net.

This book gives an account of the author's scheme for preventing the further desiccation of the central portions of South Africa, and for giving the country a greater general humidity.

The work is composed of three parts. In the first part the author deduces evidence to show that South Africa is gradually drying up, that the droughts are becoming worse year by year, and that before long the Karroo will become as desert as the Sahara unless something can be done to create a vast change in the present conditions.

In the second part attention is directed to the causes of the desiccation. It is pointed out that the water which accumulates in the interior of the country is being carried away by the rivers into the sea, and that the central districts, being too far inland to benefit by the moisture blown in from the ocean, are becoming drained.

In the third part the Kalahari scheme is described, which, it is claimed, will serve to remedy the droughts

and restore to South Africa the fertility it possessed some two or three centuries ago. The proposed scheme consists essentially of the construction of two weirs across the Cunene and Chobe Rivers. It is stated that this would cause the Etosha Pan to become filled with water and Lake Ngami to cover much of its former area, making one great lake out of the at present separated tracts of Ngami, the Mababe and Chobe Swamps. The overflow would fill the Makarikari depression which, with the Gwai and Macloutsie extensions, covers an area of 15,000 square miles. This vast expanse of water would be a source of supply for rain-clouds which would not only effect the clothing of the Kalahari sand-hills with permanent pasture, but would eventually lead to a precipitation throughout the central parts of South Africa.

The scheme has already been widely discussed, and its efficacy has sometimes been questioned. The benefits which, in the author's opinion, would accrue from its adoption are, however, of such vast importance to the future prosperity of South Africa that the scheme merits careful consideration.

The book is written in an interesting manner and is well illustrated, but there is no index.

FLAX AND ITS PRODUCTS. By H. R. Carter. Pp. viii + 311. Demy 8vo. (London: Bale & Danielsson, Ltd., 1920.) Price 10s. 6d. net.

In this BULLETIN (1918, **16**, 406) reference was made to a little book by Mr. H. R. Carter, entitled *Flax: Its Cultivation and Preparation for the Market.* As the issue of this work has now become exhausted, the author has rewritten it and added chapters giving brief descriptions of the processes of spinning, weaving and finishing of flax yarns and fabrics, the manufacture of linseed oil, and the utilisation of flax tow.

An appendix to the new book, which comprises nearly three-fourths of the whole, deals with the effects of the war on the flax industry, and the resulting situation in the years 1918–20. It consists mainly of extracts from newspapers and quotations from the reports of various flax associations and societies. These have been printed without any system or logical order, and thus one finds paragraphs on flax production, machinery, Government control of the crop, retting, cultivation, spinning, prices, and various other matters scattered about indiscriminately.

PAPER TECHNOLOGY. **An Elementary Manual on the Manufacture, Physical Qualities and Chemical Constituents** of Paper and Paper-making Fibres. By R. W. Sindall, F.C.S. Third Edition. Completely revised and rewritten. Pp. xvi + 337, with 14 plates and 202 illustrations, Med. 8vo. (London: Charles Griffin & Co., Ltd., 1920.) Price 21*s*. net.

This well-known work, which was first published in 1906, and has now reached its third edition, gives a useful, instructive and well-arranged account of the manufacture and properties of pulp and paper of various kinds. The physical and chemical characters of the raw materials and the finished paper are described, and methods of analysis and investigation are carefully and fully detailed. In addition, the book contains a chapter on the history, chronology and statistics of paper-making and on the customs of the paper trade in different countries, and useful glossaries of the technical terms used in connection with the raw materials and those applied to papers of various descriptions. The chief changes introduced in the new edition are to be found in the section devoted to the examination and analysis of the manufactured product.

The book is well illustrated, and will doubtless continue to be of great service, not only to paper-makers, but also to printers, stationers and all who are interested in the production and utilisation of pulp, paper and boards.

PAPER AND ITS CONSTITUENTS. A Manual of Technical Methods. Chemistry and Analysis of Raw Materials; Paper-making Fibres; Bleaching, Sizing and Loading Agents and Dyestuffs; Microscopy; and Physical and Chemical Properties of Papers. By Henry Aldous Bromley, F.C.S. Pp. viii + 232, Demy 8vo. (London: E. and F. N. Spon, Ltd.; New York: Spon & Chamberlain, 1920.) Price 15*s*. net.

The greater part of this work was originally published as a series of articles in the pages of the *Paper Maker*. The matter has now been revised and rearranged and forms a useful manual for students as well as a work of reference for the paper-maker.

The first part of the book gives a brief outline of the occurrence, chemical characteristics and reactions of cellulose, and a short description of the commoner fibres employed in the manufacture of paper.

The second part deals with the chemistry of the various materials used in paper-making, including bleaching

agents, sizes, mineral filling and loading agents, pigments and dyes, and water. Much of this matter, especially the short chapter on general chemistry, is too condensed to be of any great value, and would be better learned from an elementary textbook of chemistry.

The third part, which is by far the most valuable, describes the methods of examining papers with reference to their microscopical, physical and chemical properties, and will doubtless prove of considerable service to those engaged in the paper industries.

A Manual of the Timbers of the World, their Characteristics and Uses. By Alexander L. Howard. To which is appended an account by S. FitzGerald of the Artificial Seasoning of Timber. Pp. xvi + 446, 8vo. (London: Macmillan & Co., 1920.) Price 30*s*. net.

Few men can have had the long and varied practical experience of timbers which the author of this book has enjoyed, and the distinctive value of his work is that he has given us the full benefit of his forty years' practical and commercial study. In his Preface he modestly disclaims any intention of superseding previous works, and he has certainly carried out very completely his expressed purpose of supplementing them. After a brief Introduction on the national importance of timber, which opens with an impressive appeal for respect to growing trees, taken from the Portuguese, three-fourths of the volume is occupied with an alphabetical descriptive catalogue of the timbers of the world. This comprises some 450 woods (furniture and ornamental woods being included) with their scientific names, countries of origin, weight per cubic foot, "when dry," brief histological description and uses. All the woods in the British trade are included, together with many Brazilian, Philippine, Formosan, Guianan and other kinds as yet hardly heard of here. The accounts of boxwood, jarrah, African mahoganies, walnuts, and especially oaks, are particularly well done, as also is that of Oregon pine, though those of the softwoods do not in general strike one as being equally well carried out. Teak is well described, but for the absence of the almost certainly accurate identification of Surinam teak with *Andira inermis* and a confused statement on p. 285 which apparently describes an essential oil as "congealing" in the heart-shakes of the wood into the hard masses of calcium phosphate which turn the edges of the tools of the timber-worker. This omission and blunder is typical of the neglect of much

of the recent literature of the subject and the want of scientific accuracy, especially in nomenclature, which characterises the whole book. On p. 51 the author treats the synonym *Icica altissima*, Aubl. as a distinct wood from *Protium altissimum*, Marsh.; on p. 63 he speaks of "Chittagong wood" as a name applying exclusively to *Chickrassia tabularis*, Juss.; whilst the error as to the initial letter of the specific name of nutwood on pp. 163 and 432 has concealed its identity with Angélique, which is described on p. 10. In discriminating between the very different woods imported as "Japanese ash," *Fraxinus mandschurica*, or Tamo, and *Acanthopanax ricinifolium*, or Sen, the figures have been most unfortunately transposed on p. 21, Fig. A being Sen, and Fig. B Tamo; whilst on p. 266 a hopelessly confused account is given of the English, Scottish and American uses of the names sycamore, maple and plane. Strictly speaking, of course, the name sycamore belongs only to the sycamore-fig (*Ficus Sycomorus*), maple to all and any species of *Acer*, and plane to those of *Platanus*, so that our hedgerow maple (*Acer campestre*) certainly has no claim on the name sycamore, which suggests a tree valuable for shade and has never, so far as we know, been applied to it. The only confusion which exists concerns *Acer Pseudo-platanus*, the great maple, commonly called sycamore in England and plane in Scotland.

It is somewhat unfortunate that the new names attached for trade purposes to several valuable Indian woods at the recent Empire Timber Exhibition do not appear in the book, whilst their precise identity was not revealed in the official catalogue of the exhibition. Such were laurel-wood (*Albizzia Lebbek*), Indian silver-grey wood (*Anogeissus latifolia*), Indian red pear (*Bursera serrata*), Indian tulip-wood (*Dalbergia Oliveri*), yellow-heart (*Fagræa fragrans*) and red zebra-wood (*Melanorrhœa usitata*); whilst Indian white mahogany is probably *Canarium bengalense*. It would have been useful to those likely to make use of woods not yet in general commerce if some indication had been given of the whereabouts of specimens which could be inspected; but, while the author makes frequent references to the treasures of carved wood-work preserved in the Victoria and Albert Museum, he seldom mentions the extensive series of woods produced within the Empire to be seen at Kew, and never evinces any knowledge of the collection classified under countries at the Imperial Institute. It is now generally admitted that the weights of single specimens or any weights "when dry," without record of percentage of

moisture present, are of little or no practical value to the engineer ; so that we cannot but think the reprinting of the tables from Laslett's work of 1875 a mere waste of space.

The concluding quarter of the volume which is devoted to kiln-drying is an excellent exposition of a practical topic not previously adequately treated in English. On p. 321 the invention of the Powellising process is erroneously attributed to Mr. H. J. Powell, instead of the late Mr. William Powell; and the allusion to the gross commercial dishonesty described on p. 388 by which timber kiln-dried in Finland has been sold in England and elsewhere as "guaranteed not kiln-dried" strikes one as somewhat cynically indifferent. Most of the blemishes we have indicated could, however, be easily removed in the new edition which we have little doubt so useful a book will soon reach ; and, in spite of them, we have to thank Mr. Howard for a valuable addition to the literature dealing with wood.

A GUIDE TO THE IDENTIFICATION OF OUR MORE USEFUL TIMBERS, BEING A MANUAL FOR THE USE OF STUDENTS OF FORESTRY. By Herbert Stone. Pp. viii + 52, Demy 8vo. (Cambridge : University Press, 1920.) Price *7s. 6d.* net.

Our first thought, on reading the title-page of this pamphlet, was one of congratulation to the University of Cambridge on having secured the services as a teacher of one who is so admittedly a master of his subject as Mr. Stone. The Imperial Institute has had frequent occasion to recognise the thoroughness with which he investigates woods. The opinion he expresses at the outset of his little book that there is nothing better as a training in observation than a study of the structure of wood can, we think, hardly be gainsaid ; but any one going to the book on account of its title as a guide will probably be disappointed in that the possession of a knowledge of the elementary structure of wood is from the outset assumed. The book is, in fact, merely an exercise-book—an excellent exercise-book, it is true—for Mr. Stone's own pupils in the discrimination of some forty woods. In spite of its title, these are not all timbers, *i.e.* building woods, since canary whitewood, linden, West Indian mahoganies, laburnum, pear, red gum, box and hornbeam are included ; whilst some common woods, both British and exotic, that might have been looked for, such as holly, maple, cigar-box cedar, eucalyptus and African mahoganies,

do not appear. The two simple and interesting keys at the end of the book to the broad-leaved and coniferous woods included in the course are "frankly empirical," as the author does not consider "a scientific and more difficult key," such as serious students of wood would much have liked to see from his pen, desirable for his present purpose. The purpose of the book is, in fact, entirely educational, and we have no doubt that it will serve admirably for students working with such a collection of type specimens as they have at Cambridge. When, for instance, it is said (p. 26) that the wood of *Carpinus Betulus* is "not easily confused with any other except perhaps holly," reference is, it must be presumed, to those woods in this type-series, since that of the American hornbeams resembles our British species far more closely than does that of any *Ilex*.

A MAP OF THE WORLD (ON MERCATOR'S PROJECTION) HAVING SPECIAL REFERENCE TO FOREST REGIONS AND THE GEOGRAPHICAL DISTRIBUTION OF TIMBER TREES.

A MAP OF NORTH AMERICA (ON MERCATOR'S PROJECTION) HAVING SPECIAL REFERENCE TO THE PRINCIPAL FOREST REGIONS AND THE CHIEF TIMBER TREES.

A MAP OF SOUTH AMERICA, CENTRAL AMERICA AND THE WEST INDIES (ON MERCATOR'S PROJECTION) HAVING SPECIAL REFERENCE TO THE PRINCIPAL FOREST REGIONS AND THE CHIEF TIMBER TREES.

A MAP OF EUROPE AND AFRICA (ON MERCATOR'S PROJECTION) HAVING SPECIAL REFERENCE TO FOREST AREAS AND THE DISTRIBUTION OF THE PRINCIPAL TIMBER TREES.

Four wall-maps, each 37½ in. × 29 in., mounted on canvas and rollers and varnished. Prepared by J. Hudson Davies, F.R.H.S. (Edinburgh: W. & A. K. Johnston, Ltd.) Price 8*s*. 6*d*. each.

These are four well-conceived and excellently executed specimens of cartography which should be of great use in schools and in shipping or timber merchants' offices. The colouring on the main maps of all four sheets is uniform and is confined to the now familiar five tints of yellow, brown and greens representing tundra and snow, desert, grass-land and prairie, well-wooded regions in which 20 to 40 per cent. of the surface is occupied by woodland, and densely wooded areas with more than 40 per cent. so occupied. The maps are not overcrowded with place-names, those marked being chiefly ports from which timber is shipped, to which in the case of small

islands an indication of their nationality has been added; while in the world-map, which is, we think, the best of the series, the names of the leading timbers of commerce appear in admirably clear black capitals. Every corner available has been filled with useful inset maps. Thus the map of the world has two smaller world-maps on Mollweide's projection showing rainfall and isotherms with zones of tree-growth and a diagram of the vertical distribution of trees on the principal mountains of the world. The map of North America has twelve small inset maps showing the areas of twenty leading species, with notes as to those of a dozen others. The South American sheet has six inset maps of Central America and the West Indies and four of South America giving the distribution of eighteen species, with notes on fifteen others; and that of Europe and Africa has ten additional maps each comprising Europe, Asia and North Africa, and four maps of Africa, indicating the areas of about thirty species with notes on thirteen less important ones. A fifth sheet is presumably forthcoming to complete the series by showing the resources of Southern Asia and Australasia. But few slips appear for correction in the next issue. In the world-map "Hazomainti," which appears on Madagascar, is only a local name for ebony, which is separately named: on the North American sheet "Acurrubrum" appears in the legend of one of the insets for *Acer rubrum*, "Liquidamber" for *Liquidambar*, and "Liriodendron culipifera" for *L. tulipifera*; on that of South America we have "Lyseloma," "Nectandra Rodœi," and "Machærum" for *Lysiloma*, *Rodiæi* and *Machærium* respectively; and on the Europe and Africa sheet the Japanese larch appears as "Larix leptolepsis" instead of *leptolepis* and Cape box as "Buxus mocowani" instead of *Macowani*. For convenience of reference, the inset maps should have been numbered. But these are but slight defects in a scheme which Mr. Hudson Davies has in the main carried out in an admirable manner. Compared with most present-day prices, the price of this series of maps is very moderate.

PROSPECTING FOR OIL AND GAS. By Louis S. Panyity. Pp. v + 249, Med. 8vo. (New York: John Wiley & Sons, Inc.; London: Chapman and Hall, Ltd., 1920.) Price 18*s*. net.

This is a practical book by an oil and gas geologist, and should prove extremely useful to oil men and students of oil geology.

The work is divided into eighteen chapters, the first six of which deal with the composition, properties and origin of oil and gas, general geology, accumulations of oil and gas, structure and the effect of structure upon accumulations. The illustrations of types of oil and gas reservoirs, flow of connate water and gas due to compacting of the sediments, and spilling flow lines are taken from U.S. Geological Survey publications, and are well explained in the text.

Chapter VII is on surveying instruments and methods. Plane Table surveying is illustrated and described in some detail, and the attachment known as the Beaman Stadia Arc, for facilitating computations of horizontal and vertical distance, is illustrated and described.

Chapter VIII deals with topographic maps, with and without contour lines, farm and geologic maps. Isobath, or structure contour maps, isochore (equal thickness) and isopachous maps are shown and described. The last are of great importance in observing the pinching and swelling of sands, the points along the sands having equal thickness being indicated by contour lines. From these, sections of the sands along the property line can be prepared.

Chapter IX treats of geological field-work in some detail, and in Chapter X typical fossils are illustrated, and a useful table is included showing the geological range of fossils.

Chapter XI is a short one on the scouting of territories previously drilled and abandoned, and of territories where development work is being carried on. A form of scouting card is shown.

Chapters XII—XV deal with the methods of locating wells, including the spacing of wells and offsetting; drilling methods, with forms of drilling contracts, both simple and complete, spudding, the rig up and casing of wells, and the modern packer which has largely replaced the old seed-bag, with form of drilling index-card, and drilling commencement and completion notices; "bringing in" wells, with form of well log, and the shooting of wells; the completion of wells, with drips, pumping jack for pumping shallow wells, with form of combined oil-run ticket and well completion notice.

Chapter XVI is on the gauging of oil and gas wells, and illustrates the U-gauge and steam and spring gauge, and a form of oil run ticket.

Chapter XVII describes the methods of increasing production by flooding, the use of compressed air, etc. Diagrams show the effects of flood water and arrangement

of wells drilled to utilise flood water pressure, the distribution and spacing of air and pumping wells (from Bulletins of the Bureau of Mines), and the principle of natural gas storage (from a paper by the author published in the *Transactions of the American Institute of Mining Engineers*).

The last chapter deals briefly with the producer and landowner, and gives a form of oil and gas lease.

The appendix of 37 pages gives general sections of rocks met with in actual drilling, stadia and other useful tables.

The work deals with American practice throughout, and should be on the book-shelves of British oil men and students of oil geology, side by side with a good work on the prospecting and finding of oil by a British geologist. Panyity's work is intentionally more or less elementary in design, and has been written to form an introduction to, rather than to supersede, standard American and British works.

BOOKS RECEIVED

"THE TIMES" BOOK OF CANADA: DEVELOPMENT SINCE CONFEDERATION. Pp. 292, Crown 8vo. (London: *The Times*, 1920.) Price 7*s*. 6*d*. net.

THE LIFE AND TIMES OF SIR ALEXANDER TILLOCH GALT. By O. D. Sketon. Pp. 586, Med. 8vo. (Toronto: Oxford University Press, 1920.) Price 18*s*. net.

PLANTATION RUBBER AND THE TESTING OF RUBBER. By G. S. Whitby, Ph.D., M.Sc., A.R.C.Sc. Pp. xvi+559, Demy 8vo. (London: Longmans, Green & Co., 1920.) Price 28*s*. net.

A PRACTICAL GUIDE TO COCO-NUT PLANTING. By R. W. Munro and L. C. Brown. 2nd ed., with Appendix by Editor of *Tropical Life*. Pp. xx + 203, Crown 8vo. (London: John Bale, Sons & Danielsson, Ltd., 1920.) Price 15*s*. net.

THE SUGAR-BEET IN AMERICA. By F. S. Harris, Ph.D. Pp. xviii + 342, Crown 8vo. (New York: The Macmillan Company, 1919.) Price 12*s*. net.

Insect Pests and Fungus Diseases of Fruit and Hops: A Complete Manual for Growers. By P. J. Fryer, F.I.C., F.C.S. Pp. xv + 728, Demy 8vo. (Cambridge: University Press, 1920.) Price 45*s.* net.

Popular Oil Geology. By Victor Ziegler. 2nd ed. Pp. 171, Crown 8vo. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1920.) Price 15*s.* net.

Liquid Fuels for Internal Combustion Engines: A Practical Treatise for Engineers and Chemists. By Harold Moore, M.Sc. Tech., A.I.C. 2nd ed., revised and enlarged. Pp. xv + 206, Demy 8vo. (London: Crosby, Lockwood & Son, 1920.) Price 15*s.* net.

Technical Methods of Ore Analysis. By A. H. Low, B.S. 8th ed., revised and enlarged. Pp. xvi + 388, Med. 8vo. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1919.) Price 19*s.* net.

Topographic Maps and Sketch Mapping. By J. K. Finch, C.E., A.M. Pp. xi + 175, Med. 8vo. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1920.) Price 13*s.* 6*d.* net.

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Dominion, Colonial and Indian Governments.

THE COMMERCIAL UTILISATION OF AFRICAN WILD SILK

AN account of the wild silks of Africa, produced by species of *Anaphe*, has been given in this BULLETIN (1916, **14**, 167), and it has been pointed out that the caterpillars or worms are gregarious and form silken nests or colonies within which each insect spins its own cocoon. There are wide diversities in the form and structure of the nests of different species. The simplest form of nest, viz. that produced by *A. Moloneyi*, which occurs in Nigeria, consists of a flat mass of mutually adherent cocoons coated on each side with a thin layer of closely interlaced silk. *A. infracta*, however, which occurs in the Southern Provinces, Nigeria, and in Uganda, forms nests, more or less spherical in form, in which the mass of cocoons is enclosed in a continuous envelope composed of an outer, somewhat loosely spun covering, and an inner, hard, parchment-like layer.

In continuation of the investigation of the commercial value of these silks at the Imperial Institute which has been carried on in communication with the Imperial Institute Committee on Silk Production, particular attention has been devoted to the determination of the best method of degumming the silk, and to the discovery of the most effective means of treating it in order to prevent the irritation of the skin and mucous membrane which is sometimes caused by handling the raw material, due apparently to the hairs of the caterpillar.

These investigations have been carried out chiefly with the nests of *Anaphe infracta* from Uganda.

DEGUMMING

A number of experiments have been carried out at the Imperial Institute with the object of determining the best means of degumming :

(1) The outer layer of the envelope,
(2) The inner layer of the envelope, and
(3) The cocoons.

The final conclusions reached as the results of this investigation are as follows :

The Envelope.—The outer layer of the envelope degums more readily than the inner layer, but it seems doubtful whether it is worth while to degum these two portions separately, and it would probably be more economical to treat the two layers together. The tough parchment layer can be degummed satisfactorily by boiling it with a weak alkaline solution. On removing the silk from the solution the softened gum should be removed as far as possible by pressure or other means. It is also of advantage to reboil or rinse the silk in the hot solution for a few minutes. The product is then boiled with soap solution. The time required for treatment with the alkaline and soap solutions depends to some extent on the way in which the boiling is done, *i.e.* on the method of heating the liquor and the circulation of the liquor, etc. The exact time needed for boiling in any particular apparatus can only be decided by the appearance of the silk, and this can be judged without much difficulty after a little practical experience. The silk is finally washed well with hot water and dried.

This process has given satisfactory results in the laboratories of the Imperial Institute and could doubtless be employed on the commercial scale. It would be necessary in the latter case that special precautions should be adopted to ensure that the mass of silk treated becomes equally degummed throughout. The gum is not completely removed by the alkali treatment (unless unduly prolonged), but the portion remaining becomes

softened, and is subsequently extracted by the soap solution. The treatment with soap also improves the colour and lustre of the silk.

The Cocoons.—The cocoons are composed of silk of similar character to that of the envelope, but usually a good many of them are damaged and weak, and they are associated in the nests with much foreign matter.

The cocoons can be satisfactorily degummed by the method already described, but generally do not require to be boiled with the liquors for so long a time as the parchment-like layer of the envelope. Much of the foreign matter in the cocoon silk—remains of caterpillars, chrysalides, excrement, etc.—could be separated by opening up the masses of cocoons, and sifting or blowing away the dirt. This could be effected by a willowing machine.

It appears probable, however, that the cocoons would not be worth working, as, in addition to the foreign matter present, these are the chief source of the irritating hairs, and the degummed silk which they furnish is inferior to that yielded by the envelope.

It therefore seems that it would be best for the *A. infracta* nests to be separated in Africa, and that the envelope, both outer layer and parchment-like layer, after being freed from pieces of twig and other extraneous matter, should be compressed and baled for shipment, whilst the cocoons should be discarded. It may be desirable also that, before baling, the material should be partially, if not wholly, degummed as described, as the irritating property would by this means be removed.

The method which has been described above for degumming the envelopes of *A. infracta* has also been found suitable for degumming the nests of *A. Moloneyi.* In the latter case, as already explained, the nests have no distinct envelope, but consist merely of a more or less flat mass of cocoons, and the nest must therefore be treated as a whole.

Irritant Action of the Raw Silk

When the nests of *Anaphe infracta* are handled in the dry state, they are liable in some persons to cause an intense irritation of the skin and mucous membrane, owing

to the enclosed hairs of the caterpillars, but this does not occur if the nests are wet. Before separating the envelopes from the cocoons, the nests should therefore be soaked in water; the outer layer of the envelope should first be removed and the remaining portion of the nests again soaked, the inner layer of the envelope being then separated from the cocoons and again soaked before being handled further.

A large number of experiments have been carried out at the Imperial Institute with a view to ascertaining the effect of various kinds of treatment on the irritant character of the nests, and the best means of removing it; and the results may be summarised as follows:

The irritant property, which, as already stated, is suppressed when the nests are wet, becomes active again on drying. It is not affected by heating the nests in dry air at 100° C., but is much diminished by boiling them with water for two hours and subsequently drying.

In view of the possibility that the cocoons would be removed in Africa and only the envelopes exported, some experiments were made with the envelopes only, and led to the following conclusions. After passing a current of steam through the envelopes and afterwards drying them, some irritant action is still perceptible. When the envelopes are boiled with 1 per cent. solution of sodium carbonate for two hours and subsequently washed and dried, no irritant action can be detected. The irritant property is also to be removed by immersing the envelopes in 1 per cent. solution of ammonia for twenty-four hours, and afterwards washing and drying.

It seems highly probable that the action of the hairs is mechanical, as when they are softened the irritant property is destroyed, either temporarily by means of water, or permanently by treatment with alkali, in which case the gum which gives them their rigidity in the natural state is removed.

Commercial Opinions

In the earlier article on African wild silk (this Bulletin, 1916, **14**, 177) it was mentioned that the Uganda silk (*A. infracta*) had been subjected to manufacturing trials,

and that the clean, degummed silk was regarded by the manufacturers as of very satisfactory quality.

Further samples of the Uganda nests and of degummed silk prepared at the Imperial Institute, together with a summary of information on this silk, have been forwarded to a number of firms of spinners selected by the Imperial Institute Committee on Silk Production. Favourable reports have been received, and some of the firms have offered to undertake degumming trials. In general, they consider that the silk resembles tussah waste, and would meet with a demand from spinners of this material.

With regard to the nests of *A. Moloneyi* from Nigeria the opinion is that the degummed silk compares not unfavourably with that of *A. infracta* from Uganda. In point of cleanliness, however, the *A. Moloneyi* silk is inferior, as it is liable to contain débris of chrysalides. Steps are being taken to arrange for a manufacturing trial with this silk.

FURTHER INVESTIGATIONS OF MATERIALS SUGGESTED FOR THE MANUFACTURE OF PAPER

(Egypt, South Africa, Fiji, New Zealand, Brazil)

In a previous number of this Bulletin (1919, **17**, 141) an account was given of the results of examination at the Imperial Institute of a number of materials which had been investigated in order to ascertain their suitability for the manufacture of paper, and references were given to earlier reports on this subject. In the following pages a further series of such materials is dealt with.

1. Egypt

(1) *Papyrus Stems*

A sample of the stems of *Cyperus Papyrus*, stated to represent the grass in a mature condition, was received from Egypt for comparison with younger stems, previously examined (*loc. cit.*, p. 154).

The sample consisted of stems measuring from 37 to 64 in. in length, from which the flower heads had been

removed ; they resembled the young stems previously received at the Imperial Institute, but were rather greener in colour.

The results of chemical examination are shown in the following table, in comparison with those obtained with the sample of young stems :

	Present sample (mature growth). *Per cent.*	Previous sample (young growth). *Per cent.*
Moisture	10·3	10·0
Ash, expressed on the dry stems .	8·2	7·7
Cellulose, expressed on the dry stems	49·7	43·0

The stems were submitted to treatment with caustic soda under conditions similar to those used for the preparation of paper pulp on a commercial scale, with the results shown below. The results obtained on similar treatment of the previous sample are also given :

Sample.	Caustic soda used. Parts per 100 parts of stems.	Parts per 100 parts of solution.	Conditions of boiling. Time. *Hours.*	Temperature.	Parts of soda consumed per 100 parts of stems.	Yield of dry pulp, expressed on stems as received. *Per cent.*
Present sample of mature stems .	16	4·0	5	140° C.	12·5	42
Previous sample of young stems .	16	4·0	5	140° C.	10·4	34

The above results indicate that mature *Cyperus Papyrus* stems are richer in cellulose, and give a higher yield of pulp than the young stems. The unbleached pulp obtained in the present case was greyish, whilst that yielded by the young stems was brown. The pulp was, however, similar in character and composition and in its behaviour on bleaching to that obtained from the previous sample by similar treatment.

The pulp showed a tendency to shrink on drying owing to the presence of parenchyma, and under the conditions normally employed for the manufacture of paper pulp it could only be bleached to a cream tint.

The results of this investigation generally confirm those obtained with the young stems, and show that even mature papyrus stems yield a pulp which contains a quantity of parenchyma and is difficult to bleach. The stems could be utilised for the manufacture of wrapping paper, but would be unsuitable for making pulp for the

production of white paper, as they only yield a cream-coloured product on bleaching.

The stems could not be remuneratively exported from Egypt, but might be utilised locally as a source of paper pulp.

(2) *Bourdie Grass*

A consignment of "Bourdie grass" (*Typha* sp.) was forwarded to the Imperial Institute from Egypt in order to ascertain its suitability for use as a paper-making material.

The consignment weighed 1½ tons, and consisted of ten steam-pressed bales of the dried leaves which varied in colour from light brown to light green, and were from 3 ft. 6 in. to 8 ft. in length, with an average of 6 ft. A few of the flowering stems were also present.

The material was somewhat damp, containing 14·7 per cent. of moisture when received, and lost 5 per cent. of its weight on drying in the air.

The sample was submitted to chemical examination, and was found to contain :

		Air-dry material.	Dry material.
Moisture	*per cent.*	9·7	nil
Ash	*per cent.*	8·9	9·9
Cellulose	*per cent.*	38·0	42·0

Length of ultimate fibres : 0·7 to 1·2 mm., mostly about 1·0 mm.

The material was treated with a solution of caustic soda under varying conditions in order to ascertain the most favourable method of converting it into pulp. The following results were obtained :

Experiment.	Caustic soda used. Parts per 100 parts of solution.	Caustic soda used. Parts per 100 parts of air-dry grass.	Conditions of boiling. Time.	Conditions of boiling. Temperature.	Caustic soda consumed.	Yield of dry pulp expressed on the air-dry grass.
			Hours.		*Per cent.*	*Per cent.*
E	4	12	4	140° C.	9·4	37
A	4	16	4½	140° C.	—	34
C	4	18	4	140° C.	13	32
D	4	20	5	140° C.	14·5	28

The pulp produced in experiment E did not beat easily, and the paper produced was rather harsh and shrank somewhat on drying. The use of a larger quantity of caustic soda (experiment A) produced pulp of slightly better quality, but the pulp did not bleach well. More

drastic treatment (experiments C and D) caused a further reduction in the yield of pulp, but did not produce any appreciable improvement in the quality, nor did the pulps obtained bleach well.

On the whole the results indicated that the yield and quality of the pulp obtained from this material are not sufficiently good to justify the use of large quantities of relatively expensive chemicals, such as caustic soda.

Experiments were therefore made with a view to ascertaining the suitability of the lime process (which is employed for the production of pulp from cereal straws) for treating this material, and the following results were obtained :

Experiment.	Lime (CaO) used. Parts per 100 parts of liquor.	Parts per 100 parts of material.	Conditions of boiling. Time.	Temperature.	Yield of dry pulp expressed on the air-dry material.
			Hours.		*Per cent.*
F	2·0	20	4	140° C.	38
G	2·5	25	10	140° C.	31

The pulp obtained in experiment F yielded a brown paper of fair quality. The more prolonged treatment with a larger quantity of lime gave a reduced yield of pulp of rather better quality, but the pulp did not bleach well.

The pulps prepared from these Bourdie leaves contained a large amount of parenchymatous matter derived from the pith, and the paper is consequently rendered somewhat harsh and parchment-like.

None of the experiments made with either the soda process or with the lime process yielded a pulp bleaching readily to a really pale colour suitable for the production of white paper of good quality.

These Bourdie leaves give a somewhat low yield of pulp, viz. about 35 per cent. of dry pulp from the air-dry material. The freshly gathered leaves would, of course, furnish lower yields depending on the amount of moisture present. In view of the low yield of pulp it is unlikely that the leaves could be profitably exported from Egypt for use in the United Kingdom as a paper-making material.

The pulp yielded by the leaves is of moderate quality only, but it should be suitable for the production of brown wrapping paper or cardboard. It has not been found

possible so far to bleach the pulp satisfactorily, and it seems unlikely that the pulp could be used for the production of white papers.

A cheap process for the production of pulp from grasses has been introduced by a British firm of paper-making engineers, and the Imperial Institute arranged to have trials made with the Bourdie leaves by this method. The results, however, were not favourable, and the firm stated that it would not be possible to produce a white paper economically from the material, and that although it could be treated very cheaply by their process for the production of brown paper the product is poor in comparison with paper made from ordinary straw.

A consignment of pulp prepared in Egypt from Bourdie grass was received for examination in June 1917. The material, which was dark brown and fibrous, appeared to have been subjected only to comparatively mild treatment, as in a large portion of the sample the structure of the original stems was still visible. The pulp had a faintly alkaline reaction.

The material was examined in comparison with pulp prepared at the Imperial Institute from a sample of Bourdie grass from Egypt, and with the grass itself. The results were as follows :

			Present sample.	Pulp prepared at the Imperial Institute from Bourdie grass.	Bourdie grass (air-dry).
	Moisture .	*per cent.*	9·4	—	9·7
Expressed on the dry material	Ash .	*per cent.*	11·3	2·0	9·9
	Cellulose .	*per cent.*	66·0	73·0	42·0
	Length of ultimate fibres . . .		0·5 to 1·2 mm., mostly 0·7 to 0·9 mm.	0·7 to 1·2 mm., mostly about 1·0 mm.	—

The pulp made in Egypt contained a much larger amount of mineral matter (ash) than that prepared from the grass by the soda process at the Imperial Institute, and a lower percentage of cellulose. The mineral matter consisted largely of calcium salts.

The crude material was somewhat difficult to beat into pulp suitable for the production of paper, and it appeared to be insufficiently boiled. It yielded a harsh, stiff paper, which shrank a good deal on drying, and was distinctly

inferior to the pulps prepared at the Imperial Institute from Bourdie grass by treatment with 12 or 16 per cent. of caustic soda for four hours at 140° C. (see p. 325).

The Egyptian pulp contained a considerable quantity of parenchymatous matter, much of which was removed on prolonged washing in the beater. The crude material yielded 71 per cent. of washed pulp which furnished a paper of better colour than that yielded by the unwashed pulp, but which was still harsh and did not bleach well, even when treated with much larger amounts of chemicals than could be economically employed on a commercial scale.

This Bourdie grass pulp from Egypt was only partially prepared, and would require further treatment in order to convert it into a form suitable for paper-making. It did not bleach well, and would probably only be suitable for the production of brown wrapping paper. In these circumstances it is improbable that it would be remunerative to export the pulp to Europe.

2. South Africa

Kokerboom

The kokerboom (*Aloe dichotoma*) is one of the largest of the South African aloes, reaching a height of 15–25 ft. or more, with a much-branched trunk, 2–3 ft. in diameter at the base. It is found in Namaqualand, generally scattered over the hills, but in some parts it forms small forests several square miles in extent (Marloth, *The Flora of South Africa*, vol. iv, 1915, p. 91). Portions of the stem of the tree were received for examination as a paper-making material in March 1919. They were about 6 in. to 7½ in. thick, and were covered with a thin, parchment-like bark, which was brown on the outside and green on the inner surface. The outer portion of the stem beneath the bark was rather dense and about ¾ in. thick, whilst the inner portion was composed of much looser fibre surrounded by parenchymatous matter and containing a great deal of water.

On removing the bark and allowing the material to dry in the air it was found that 100 parts of the original stem

yielded 21·4 parts of air-dried decorticated material. The latter was analysed with the following results :

	Per cent.
Moisture	9·0
Ash	7·0
Cellulose	42·1[1]

[1] *Equivalent to 9·0 per cent. of cellulose in the moist stems as received.*

The ultimate fibres were of good length (2·0 mm. to 4·4 mm.), but they were rather coarse and harsh.

The air-dried decorticated stems were treated with caustic soda under conditions similar to those used in the manufacture of paper pulp on a commercial scale, and the results are shown in the following table :

Experiment.	Caustic soda used.		Conditions of boiling.		Soda consumed per 100 parts of fibre.	Yield of dry pulp expressed on air-dry decorticated stem.
	Parts per 100 parts of stem.	Parts per 100 parts of solution.	Time.	Temperature.		
			Hours.			*Per cent.*
A[1]	16	2·8	8	140° C.	—	—
B	16	2·8	6	160° C.	9·3	46
C	24	4·8	6	140° C.	13·8	41

[1] *Under the conditions of this experiment the material was not softened sufficiently to enable it to be readily broken up.*

The pulps produced in experiments B and C furnished a fairly strong, opaque brown paper which could not be bleached.

A further experiment was carried out with the entire air-dried stems, including the bark, under conditions similar to those employed in experiment B. The bark broke up readily, but only yielded cellulose of a non-fibrous nature which was mostly removed in washing the pulp. The entire stems treated in this way yielded 40 per cent. of pulp.

The air-dried kokerboom stem gives a fair yield of pulp, but the product is only of moderate quality, as it cannot be bleached even when it has been prepared by fairly drastic treatment.

The fresh stems must contain a very large amount of water, as the present sample lost nearly 79 per cent. of its weight on air-drying after receipt at the Imperial Institute. It would thus obviously be commercially impracticable either to carry the fresh material any considerable distance to a pulp mill or even to treat it locally in

digesters, as it would only yield about 8 per cent. of pulp. The stems would require either to be cut up and dried before treatment or to be crushed to get rid of most of the water.

These results show that, on the whole, kokerboom is not a promising paper-making material, and that it is inferior for this purpose to other South African products, such as the Tambookie and other grasses which have been examined at the Imperial Institute (cf. this BULLETIN, 1918, **16**, 127; 1919, **17**, 141).

3. FIJI

Vau Stems

"Vau" is the Fiji name for *Hibiscus tiliaceus*, Linn., a small tree or bush, widely distributed in the tropics. The stems yield a bast fibre of fair quality, which is used in India for making ropes. The wood, sometimes known as "cork wood," is employed in some of the Pacific islands for making boats; in India it is used mainly for fuel and occasionally for hut-building. Pieces of the young stems from Fiji, 12 in. in length and consisting of fibrous bark enclosing a soft wood, have been investigated as a paper-making material. They had the following composition:

	Per cent.
Moisture	9·3
Ash	1·8
Cellulose, in material as received	45·2
Cellulose, expressed on the dry material	49·9

Length of ultimate fibres: from 0·8 to 1·6 mm.; average, 1·2 mm.

On treatment with caustic soda under conditions similar to those employed on a commercial scale in the preparation of paper pulp the following results were obtained:

Experiment.	Caustic soda used. Parts per 100 parts of stems.	Caustic soda used. Parts per 100 parts of solution.	Conditions of boiling. Time.	Conditions of boiling. Temperature.	Parts of caustic soda consumed per 100 parts of stems.	Yield of dry pulp expressed on stems as received.
			Hours.			*Per cent.*
A	16	3	7	140° C.	11·1	54
B[1]	16	2·5	5	160° C.	12·4	46
C	22	4	6	160° C.	13·2	36

[1] *In this experiment the bark was removed from the stems and the wood only employed.*

When boiled under the usual conditions, *i.e.* with a low percentage of caustic soda, the stems gave a good yield of pulp, which, however, did not break up completely and could not be bleached. The removal of the bark before the preparation of the pulp in experiment B did not appear to make any appreciable difference to the pulp obtained.

A better product was obtained on treating the stems under the more drastic conditions of experiment C, but even in this case the pulp did not beat very well, and could only be bleached to a cream colour.

The average length of the ultimate fibres (1·2 mm.) is rather short, and the pulp is consequently of somewhat poor quality.

The stems give a good yield of pulp when subjected to mild treatment with caustic soda, but the quality of the pulp is rather inferior. The stems could not be profitably exported in the raw condition, and it is probable that if they were converted into pulp in Fiji the pulp would not be of sufficient value for export, although it would be suitable for the manufacture of wrapping paper for local use.

4. New Zealand

Matai Wood

Matai or black pine (*Podocarpus spicatus*) is a large coniferous tree, 40–80 ft. high, with a trunk 2–4 ft. in diameter. It occurs in the forests throughout New Zealand, from North Cape southwards. The wood has recently been examined in order to ascertain its value as a paper-making material. The specimens tested consisted of blocks of wood from which the bark had been removed. The wood was hard and had an uneven grain; it was mainly reddish-brown, but was streaked unevenly with a darker tint.

The wood was analysed with the following results :

	Per cent.
Moisture	8·6
Ash	0·1
Cellulose, expressed on wood as received	23·3
Cellulose, expressed on the dry wood	25·4

Length of ultimate fibres : 1·5 to 4·0 mm.; average, 2·9 mm.

The wood thus gave only a low yield of cellulose, but the ultimate fibres were of good length.

The wood was examined as a paper-making material by treatment with caustic soda under conditions similar to those employed on a commercial scale, and the results are given in the following table :

Experiment.	Caustic soda used. Parts per 100 parts of wood.	Caustic soda used. Parts per 100 parts of solution.	Conditions of boiling. Time.	Conditions of boiling. Temperature.	Caustic soda consumed per 100 parts of wood.	Yield of dry pulp expressed on wood as received.
			Hours.			*Per cent.*
A[1]	16	3	8	160° C.	9·6	25
	12	3	6			
B	22	4	18	160° C.	9·6	25

[1] *Treatment for eight hours with sixteen parts of caustic soda proved insufficient, and the material was therefore further digested for six hours and with twelve parts of caustic soda.*

The wood thus required drastic treatment with caustic soda, and gave only a small yield of pulp. The pulp obtained, however, had very good felting properties, and yielded paper of good strength, but could not be satisfactorily bleached.

The yield of pulp from this Matai wood is low, and from the results obtained it seems unlikely that the wood could be profitably employed as a paper-making material.

5. Brazil

(1) *Tabocca Brava*

A bamboo from Brazil was received under the name of "Tabocca Brava" for examination as a source of paper pulp.

The sample consisted of pieces of dull straw-coloured bamboo cane, measuring 19 in. in length and having an external diameter of about 1½ in.

The material was analysed as a paper-making material with the following results :

	Per cent.
Moisture	9·8
Ash	3·3
Cellulose, expressed on the cane as received	49·9
Cellulose, expressed on the dry cane	55·3

Length of ultimate fibres : from 1·0 to 2·6 mm. ; average, 1·7 mm.

The material was treated with caustic soda, under conditions similar to those employed in the preparation of paper pulp on a commercial scale, with the results given in the following table :

Experiment.	Caustic soda used. Per 100 parts of stem.	Per 100 parts of solution.	Conditions of boiling. Time.	Temperature.	Caustic soda consumed per 100 parts of stem.	Yield of dry pulp on stems as received.
			Hours.			*Per cent.*
A	16	3	8	140° C.	10·3	48
B	16	3	6	160° C.	9·6	49
C	16	4	12	140° C.	10·6	48

In these experiments good yields of pale-coloured pulp were obtained, furnishing fairly soft papers. On treatment with bleaching agents, it was found that the pulp could not be satisfactorily bleached, and that its colour was only slightly reduced.

As the pulp appeared to possess good felting properties, an attempt to produce white paper from the cane was made on the following lines :

The cane was digested for ten hours with water at 160° C. to remove starch and similar bodies, and was then treated by the sulphate process at 160° C. for six hours. This treatment gave a yield of 36·5 per cent. of dry pulp (calculated on the stems as received) which was slightly darker than that furnished by the soda process, was free from parenchyma and possessed excellent felting properties. This pulp bleached fairly readily, and yielded a white paper of good quality.

Further experiments in the production of white paper by this method were not possible with the small quantity of material available.

Tabocca Brava furnishes on moderately drastic treatment a good yield of pulp of fairly high quality, and suitable for wrapping and similar classes of papers. It would appear that white paper cannot be obtained from it by means of the soda process, but promising results in this direction were obtained by the sulphate method.

Owing to the bulky nature of the stems it is unlikely that it would be remunerative to ship them to this country, and it would therefore be necessary to convert them into pulp in Brazil.

(2) *Aninga Stems*

The Aninga plant (*Montrichardia arborescens*, Nat. Ord. Aroideæ) occurs abundantly in parts of Brazil, and considerable attention has been paid in recent years to the possibility of extracting the fibre for use as a cordage material and utilising the stems as a source of paper pulp.

Description

Pieces of stem about 18 in. in length and from 2 to 3½ in. in diameter were received from Brazil for examination at the Imperial Institute in April 1920. The stems bore a thin reddish-brown bark and contained a large amount of pith. The straw-coloured fibres were most numerous towards the outside of the stem, and were rather sparingly distributed in the centre.

The material had the following composition:

	Per cent.
Moisture	10·1
Ash	7·9
Cellulose, in material as received	45·0
Cellulose, expressed on the dry material	50·1

Length of ultimate fibres: 1·8 to 3·7 mm., with an average of 2·4 mm.

A quantity of the stem was treated with caustic soda under conditions similar to those employed in the preparation of paper pulp on a commercial scale, with the results shown in the following table:

Experiment.	Caustic soda used. Parts per 100 parts of stem.	Caustic soda used. Parts per 100 parts of solution.	Conditions of boiling. Time. *Hours.*	Conditions of boiling. Temperature.	Soda consumed per 100 parts of stem.	Yield of dry pulp expressed on stems as received. *Per cent.*
A	16	2	5	140° C.	8·0	42·5
B	16	2	8	140° C.	9·5	37·5
C	16	2	6	160° C.	10·2	37·0

A moderately good yield of pulp was obtained in experiment A, but the pulp was very difficult to break up, and the paper produced, although strong, would only be suitable for wrapping purposes. Under the more drastic conditions of experiments B and C the stems yielded less pulp, but much better and stronger papers were obtained. In no case, however, did the pulp bleach satisfactorily, and the paper obtained as the result of bleaching the pulp from experiment C was still pale brown.

The results show that Aninga stems would yield a pulp

furnishing a good brown paper, but the pulp cannot be bleached to a sufficiently pale tint for the manufacture of paper suitable for writing or printing purposes. The removal of the outer bark from the stem would not appreciably improve the value of the material for paper-making.

INDIAN KAPOK SEED AS A SOURCE OF OIL

THE silk cotton known as Indian kapok is derived from the capsules of *Bombax malabaricum*, DC., a large deciduous tree found throughout India and Ceylon. The plant is now usually included, with *Eriodendron anfractuosum*, the source of Java kapok, and others, in the natural order Bombacaceæ, but the group is sometimes regarded as a tribe of the Malvaceæ. It has been shown by the Imperial Institute that Indian kapok in a reasonably clean condition fully satisfies all the requirements of the Board of Trade for kapok for use in life-buoys and other life-saving appliances as regards buoyancy and impermeability to water, and is therefore as suitable for this purpose as Java kapok (cf. this BULLETIN, 1919, **17**, 14).

Indian kapok, like that from *Eriodendron*, surrounds the seeds in the capsule, and in preparing the fibre for the market the seeds are separated. If the Indian kapok is utilised to any great extent, therefore, large quantities of the seed will be available. It is known that the seed yields an oil, which is used to a small extent in India for burning.

The recorded information regarding Indian kapok seed as a source of oil, however, is not very definite, owing to the fact that little distinction has been made in the past between the seed of Indian kapok and that of Java kapok. In these circumstances the Director-General of Commercial Intelligence was requested by the Imperial Institute to forward an authentic sample of Indian kapok seed, in order that the yield and nature of the oil might be determined and the commercial value of the seed ascertained. A sample consisting of small dark brown seeds of *Bombax malabaricum* was received in May 1920, and the results of the examination of the seed at the Imperial Institute are given below.

The seeds contained 8·9 per cent. of moisture and yielded on extraction with petroleum ether 22·3 per cent. of oil, equivalent to a yield of 24·5 per cent. from the dry seeds.

The oil, which was bright yellow, deposited some "stearin" on standing. It was examined with the following results, which are compared with previous figures recorded for Indian kapok oil, and for commercial kapok oil derived from the seeds of *Eriodendron anfractuosum* :

	Bombax malabaricum oil. Present sample.	*Bombax malabaricum* oil. Figures previously recorded.	Commercial kapok oil.
Specific gravity at 15°/15° C.	0·9208	0·930	0·921–0·923
Acid value	9·3	3·0	variable
Saponification value	193·3	194 3	190–197
Iodine value . . . *per cent.*	78·0	73·6	95–110
Volatile acids, soluble	nil	—	—
Volatile acids, insoluble	0·5	—	—
Unsaponifiable matter . *per cent.*	1·0	—	—
Refractive index at 40° C. n_D	1·461	—	—
Solidifying point of fatty acids	38·0° C.	—	—

From these results it will be seen that the constants of the two varieties of oil are generally similar, but that the iodine value of the oil of *Bombax malabaricum* is considerably lower than that of ordinary Java kapok oil.

The residual meal left after the extraction of the oil from the seeds was greyish white, and had a mild and not unpleasant taste. It was examined with the following results, which are shown in comparison with the corresponding figures recorded for undecorticated cotton-seed cake and commercial kapok-seed cake :

	Meal from *Bombax malabaricum* seeds. Composition of extracted meal.	Meal from *Bombax malabaricum* seeds. Composition of meal containing 7 per cent. of fat.	Undecorticated cotton-seed cake.	Commercial kapok-seed cake.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	11·4	10·7	13·75	13·80
Crude proteins	36·5	34·2	24·62	26·25
Fat	0·8	7·0	6·56	7·47
Carbohydrates, etc. (by difference)	24·7	23·1	29·28	23·19
Fibre	19·9	18·7	21·19	23·19
Ash	6·7	6·3	4·60	6·10
Nutrient ratio[1]	1 : 0·7	1 : 1·2	1 : 1·67	1 . 1·5
Food units[2]	118	126	107	107

[1] *The ratio between the percentages of crude proteins and the sum of the percentages of starch and fat, the latter being first converted into its starch equivalent.*

[2] *The total obtained by adding the percentage of starch to 2·5 times the sum of the percentages of fat and crude proteins.*

The Bombax meal is thus seen to be much richer in proteins than commercial kapok-seed cake, and to have a higher nutritive value than undecorticated cotton-seed cake.

The residual meal of Java kapok seed is regarded as of low value, and is principally used as an ingredient in compound feeding cakes, but the foregoing results indicate that the meal from Indian kapok seed would be a more valuable feeding-stuff.

A firm of oil-seed crushers, who examined the seed at the request of the Imperial Institute, reported that the yield of oil was rather higher than that generally obtained from Java kapok seed. The oil also appeared to be of better quality than that from the latter seed and more likely to be suitable for refining for edible purposes. If this were confirmed by commercial trials the firm were of opinion that Indian kapok seed would eventually be readily saleable, if available in commercial quantities, at a slightly higher price than the Java variety. No definite value can, however, be assigned to the oil until it has been thoroughly tested commercially.

This investigation has shown that Indian kapok seed is a promising source of oil, and that if it can be regularly shipped to the United Kingdom in commercial quantities it should find a ready market at prices equal to or higher than those realised by ordinary commercial kapok seed, which at the present time (November 1920) is worth about £15 per ton in the United Kingdom.

In view of these results it was pointed out to the Indian authorities that it seems desirable that enquiries should be made as to the quantity of kapok seed available annually in India for export, and as to the price at which it could be offered in London. If these enquiries indicate that there are reasonable prospects of establishing a trade in the Indian seed, it was suggested that a trial consignment of about 10 tons should be forwarded to the Imperial Institute for sale in London, so that a definite opinion as to the quality and value of the oil may be obtained.

AROMATIC GRASS OILS

A NUMBER of grasses belonging to the genera *Cymbopogon*, *Andropogon* and *Vetiveria* yield essential oils, some of which are of considerable commercial importance. Citronella oil is produced chiefly in Ceylon and Java, that from the former being obtained from "Lena batu" (a form of *Cymbopogon Nardus*, Rendle), whilst the Java oil is derived from "maha pengiri" grass (*C. Winterianus*, Jowitt). Similar oils, of less importance commercially, are obtained from the "Mana" grass of Ceylon (*C. Nardus*, var. *Linnaei* (typicus) and *C. Nardus*, var. *confertiflorus*). Lemon-grass oil is obtained from *C. flexuosus*, Stapf, and *C. citratus*, Stapf; the former yields East Indian lemon-grass oil, which is of the "soluble" type, being soluble to a clear solution in two or more times its own volume of 70 per cent. alcohol, whilst *C. citratus*, which is widespread in the tropics, yields the so-called West Indian lemon-grass oil, an "insoluble" oil, which as a rule is not completely soluble even in ten times its volume of 90 per cent. alcohol.

C. Martini, Stapf, an Indian grass, occurs in two forms: (*a*) "motia," which yields palmarosa, rusa or rosha oil, and (*b*) "sofia," from which the inferior ginger-grass oil is obtained. Although yielding different types of oil, the two forms do not appear to exhibit any definite botanical differences.

Another important grass oil is vetiver or cus-cus oil, which is derived from the roots of *Vetiveria zizanioides*, Stapf, indigenous to India and Ceylon and introduced into many other parts of the tropics. Vetiver roots are mainly exported from India and Java for distilling in Europe, and an inferior oil is produced in Réunion.

The results of examination at the Imperial Institute of a large number of the better-known grass oils, as well as of some less important ones, from various parts of the Empire, have been published from time to time in this BULLETIN, and in the following pages others are dealt with. For convenience of reference the following list of articles already published may be given: Citronella oil (1905, **3**, 229; 1908, **6**, 109; 1911, **9**, 241); lemon-grass oil (1904, **2**, 166; 1908, **6**, 108; 1911, **9**, 334; 1912, **10**,

546; 1914, **12**, 222; 1916, **14**, 381); vetiver oil (1912, **10**, 31; 1914, **12**, 225); *Cymbopogon coloratus* oil (1912, **10**, 27; 1914, **12**, 48); *C. polyneuros* (1912, **10**, 29); *C. sennaarensis* (1912, **10**, 31).

Citronella Oil from Seychelles

The sample of citronella oil which is the subject of this report was forwarded to the Imperial Institute in April 1918. It was stated that the citronella grass from which the oil was prepared had been introduced into Seychelles from Ceylon. The yield of oil was stated to have been 0·4 per cent.; the yield in the case of Ceylon citronella ranges from 0·42 to 0·56 and of Java citronella oil from 0·50 to 0·77 per cent.

The sample consisted of a pale-yellow oil, which was slightly cloudy and contained a small amount of a red flocculent deposit. The oil had a slightly pungent citronella odour.

The oil was submitted to chemical examination with the following results, which are shown in comparison with the figures for Ceylon and Java citronella oils:

	Present sample.	Ceylon citronella oil.	Java citronella oil.
Specific gravity at 15°/15° C.	0·881	0·898 to 0·920	0·882 to 0·898
Optical rotation at 20° C.	−28° 30′	−7° to −18° (rarely −20°)	−2° to −3° (rarely +2° to −5°)
Refractive index at 20° C.	1·477	1·4785 to 1·4900	1·4640 to 1·4725
Total acetylisable constituents calculated as geraniol . *per cent.*	52·2	Should not fall below 57; often reaches 60 to 65	80 to 94
Geraniol . *per cent.*	27·5	—	35 to 45
Citronellal . *per cent.*	24·7	—	35 to 50
Solubility in 80 per cent. alcohol.	Insoluble at 15° C.; soluble in 1·7 vol. at 20° C., becoming turbid with 10 vols.	Both oils soluble in 1 to 2 vols., with no appreciable turbidity up to 10 vols.	

The oil was of poor quality, and a firm of brokers in London stated that its value would be quite nominal. Good Java citronella oil was worth 5*s.* 6*d.* per lb. in London at that time (February 1919), and the usual quality of Ceylon citronella oil was quoted at 3*s.* 6*d.* per lb.

The present sample shows more resemblance to the

citronella oil from Ceylon than to the Java oil. It is, however, inferior to the former as regards the total acetylisable constituents and solubility, and none of its constants falls within the range specified for commercial Ceylon citronella oil.

The Seychelles authorities have been asked to forward to the Imperial Institute botanical specimens of the grass from which the oil was prepared, so that its identity can be definitely established.

LEMON-GRASS OILS FROM SEYCHELLES

I. A sample of lemon-grass oil was forwarded from Seychelles in April 1918. It was stated to have been obtained from *Cymbopogon Schoenanthus*, which has been grown in Seychelles for a long period. This species, the *Andropogon Schoenanthus* of Linnæus, is now usually known as *Cymbopogon citratus*, Stapf, and is the source of West Indian lemon-grass oil.

The sample consisted of a clear, pale-yellow oil, with the pungent characteristic odour of lemon-grass.

The oil was submitted to chemical examination for comparison with lemon-grass oils from the East and West Indies, and with previous samples from Seychelles received at the Imperial Institute (see this BULLETIN, 1908, **6**, 109). The results are shown in the following table :

	Present sample of Seychelles lemon-grass oil.	Previous samples of Seychelles lemon-grass oil examined at the Imperial Institute.	West Indian lemon-grass oil.	East Indian lemon-grass oil derived from *C. flexuosus*.
Specific gravity at 15°/15° C.	0·883	0·887 to 0·923	0·870 to 0·912	0·899 to 0·905
Optical rotation at 20° C.	−0° 12′	−0°56′ to +0°10′	−1° to +0°12′	−5° to +1°25′
Refractive index at 20° C.	1·486	—	1·482 to 1·489	1·483 to 1·488
Citral (determined by the bisulphite method) *per cent.*	78·5	50 to 74	53 to 83	70 to 85
Solubility in 70 per cent. alcohol	Insoluble	Insoluble	Insoluble	Soluble in 1·5 to 3 vols.
Solubility in 80 per cent. alcohol.	Practically soluble in 0·9 vol. at 15° C., becoming turbid on dilution.	Insoluble	Soluble in a few vols., but becoming turbid on further dilution.	—

The oil was submitted to brokers, who valued it at about *6d.* per oz. in London, when commercial lemon-grass oil was quoted at *8d.* per oz. (February 1919).

The results of the investigation show that the present sample of lemon-grass oil from Seychelles is of similar character to the West Indian lemon-grass oil, being "insoluble" and of low specific gravity. The sample is of excellent quality for this type of oil and contains a satisfactory percentage of citral, slightly higher than that in any of the previous samples of Seychelles lemon-grass oil examined at the Imperial Institute.

It was suggested that botanical specimens of the grass from which this oil was prepared should be forwarded to the Imperial Institute in order that its identity could be definitely established.

II. A sample of oil stated to have been derived from a variety of lemon-grass (*Cymbopogon flexuosus* ?) introduced into the Colony from Cochin in 1911 was received with the preceding sample. It consisted of clear golden-yellow oil with a somewhat pungent odour resembling that of lemon-grass and also that of citronella oil.

The oil was submitted to chemical examination for comparison with the figures recorded for the oil of *Cymbopogon flexuosus*, with the following results :

	Present sample.	Oil of *Cymbopogon flexuosus.*
Specific gravity at 15°/15° C.	0·898	0·899 to 0·905
Optical rotation at 20° C.	−10° 12′	−5° to + 1°25′
Refractive index at 20° C.	1·484	1·483 to 1·488
Citral (determined by the bisulphite method) . . . *per cent.*	38	70 to 85
Geraniol . . . *per cent.*	20·5	—
Solubility in 70 per cent. alcohol	Insoluble	Soluble in 1·5 to 3 vols.
Solubility in 80 per cent. alcohol	Soluble in 1 vol. at 15° C., becoming slightly turbid with 3 vols.	—

The results of the examination show that this oil from Seychelles differs markedly in composition from the oil of *Cymbopogon flexuosus.*

A firm of brokers, to whom a sample of the oil was submitted, stated that the value of oil containing only 38 per cent. of citral would be quite nominal in competition with

good Cochin lemon-grass oil containing over 70 per cent. of citral.

The results of this investigation suggest that this "lemon-grass" oil is not derived from *Cymbopogon flexuosus*, but from some other species. It behaves more like a mixture of lemon-grass and citronella oils. Botanical specimens of the plant yielding this oil have been asked for, in order that its botanical identity may be established.

Palmarosa Oil from India

A sample of palmarosa oil from the United Provinces was received in 1917. The oil as received contained an appreciable amount of dirt, and was not easily clarified by repeated filtration. The filtered oil was light yellow in colour, and had the rose-like odour characteristic of palmarosa oil.

The results of examination of the oil, compared with commercial palmarosa oil, are shown in the following table:

	Present sample.	Commercial palmarosa oil.
Specific gravity at 15°/15° C.	0·889	0·887 to 0·90
Optical rotation α_D	− 0·41°	+ 6° to − 3°
Refractive index $n_{D20°}$	1·477	1·472 to 1·476
Acid value	1·6	0·5 to 3·0
Ester value	11·8	12 to 48
Acetyl value	268·8	226 to 274
Total alcohols, calculated as geraniol *per cent.*	90·7	74·8 to 94·8
Solubility in 70 per cent. alcohol	Soluble in 1·8 vol.	Soluble in 1·5 to 3 vols.

The sample was valued at 16*s*. per lb. in London (August 1918).

This oil contained a high percentage of total alcohols, and apart from the cloudiness (which could probably only be entirely removed by redistillation) was obviously of good quality. Essential oil merchants regarded it as a normal palmarosa oil, but mentioned that the odour was not quite so good as that of the usual prime importations, having a slight lemon flavour, and not the clean geraniol odour of palmarosa oils of the highest grades.

A second sample of palmarosa oil, distilled at Cawnpore, was forwarded in March 1920, in order that further commercial action might be taken by the Imperial Institute.

It consisted of two 1 lb. bottles of clear pale-yellow oil, which had the characteristic odour of palmarosa oil.

The oil furnished the following results on examination, which are compared with those given by the previous sample from the United Provinces, and with the figures recorded for commercial samples of palmarosa oil :

	Present sample.	Previous sample from United Provinces.	Palmarosa oil (commercial samples).
Specific gravity at 15°/15° C.	0·889	0·889	0·887 to 0·90
Optical rotation $a_{D}20°$	+ 0·32°	−0·41°	−3° to +6°
Refractive index $n_{D}20°$	1·472	1·477	1·472 to 1·476
Acid value	0·8	1·6	0·5 to 3
Ester value	28·0	11·8	12 to 48
Acetyl value	261·4	268·8	226 to 274
Total alcohols, calculated as geraniol . . *per cent.*	85·5	90·7	74·8 to 94·8
Solubility in 70 per cent. alcohol	Soluble in 1·9 vol.	Soluble 1·8 vol.	Soluble in 1·5 to 3 vols.

The results show that the present sample of palmarosa oil is of good quality, but the aroma is not quite equal to that of the previous sample and it contains a lower percentage of total alcohols.

The firms who expressed interest in the earlier sample of this oil reported favourably on the present sample, and three of them asked to be put into communication with the distillers of the oil with a view to arranging business. Palmarosa oil is at present quoted in London at about 26*s.* per lb. (August 1920), which is more than double the pre-war figure (11*s.* per lb., June 1914).

The second sample of palmarosa oil was not quite equal in quality to the first, but there is little doubt that such oil would find a ready market in London under normal conditions.

Ginger-grass Oil from India

I. Two samples, described as sofia oil, were forwarded to the Imperial Institute by the Forest Economist at Dehra Dun in April 1916.

The samples (A and B) each consisted of pale-yellow oil, with a pleasant and characteristic odour. They were examined at the Imperial Institute with the following

results, compared with the corresponding figures recorded for palmarosa and ginger-grass oils :

	Sample A.	Sample B.	Palmarosa oil.	Ginger-grass oil.
Specific gravity at 15°/15° C.	0·910	0·907	0·887 to 0·90	0·90 to 0·953
Optical rotation α_D	− 15°48′	−14°3′	+ 6° to −3°	+54° to − 30°
Acid value	2·3	1·5	0·5 to 3·0	up to 6·2
Ester value	25·7	19·8	12 to 48	8 to 29
Ester value after acetylation	170·5 [1]	180·6 [1]	226 to 274	120 to 200
Solubility in 70 per cent. alcohol	Soluble in 2·1 vols. at 15° C., with no opalescence on dilution to 10 vols.	Soluble in 2·0 vols. at 15° C., with no opalescence on dilution to 10 vols.	Soluble in 1·5 to 3 vols.	Soluble in 2 to 3 vols., becoming opalescent on further dilution.

[1] *Equivalent to* 51·6 *and* 55·6 *per cent. of total alcohols, or* 44·6 *and* 50·2 *per cent. of free alcohols, respectively, in samples A and B.*

A firm of soapmakers to whom samples of the oils were submitted stated that they did not regard these as representing the highest quality of ginger-grass oil, but added that ginger-grass oil is so variable in quality that they only buy it on sample. They mentioned that at that time ginger-grass oil was scarce in the English market and worth 8*s*.–9*s*. per lb., according to quality (October 1916).

A firm of dealers in essential oils considered that the value of the samples as ginger-grass oil was lowered by the slight odour of citral (the chief constituent of lemon-grass oil) which they possessed, and, judging from this and the specific gravities of the oils, the firm were doubtful whether the alcohols present were identical with those of commercial ginger-grass oil. They were therefore unable to suggest a definite value for the oils.

The analytical results recorded above show that the constants of these oils fall well within the rather wide range of constants which have been recorded for ginger-grass oil. The specific gravities are, however, lower and the ester numbers rather higher than those frequently recorded for this oil (cf. *Indian Forest Records*, 1916, 5, 16).

With regard to the remarks made by the essential oil dealers as to the possible presence of citral in these oils, an

absorption test with sodium hydrogen sulphite showed that A contained 12 per cent. and B 11 per cent. of matter absorbed by this reagent, whilst a commercial ginger-grass oil examined in comparison gave an absorption of 10 per cent. There is therefore no reason for supposing that these samples are abnormal in this respect.

II. A further sample of ginger-grass oil was received from the United Provinces in 1917. It consisted of a clear pale-brown mobile oil with the distinctive odour of ginger-grass oil. A small amount of dirt was present which separated out completely on standing, leaving the liquid clear. It was examined with the following results, which are compared (1) with the recorded figures for ginger-grass oil and (2) with those given by a commercial sample examined at the Imperial Institute:

	Present sample.	Figures for comparison. (1)	(2)
Specific gravity at 15°/15° C.	0·936	0·90 to 0·953	0·944
Optical rotation α_D	+42·87°	+54° to −30°	—
Refractive index $n_{D20°}$	1 490	1·478 to 1·493	—
Acid value	4·5	Up to 6·2	3·2
Ester value	13·5	8 to 29	28·0
Acetyl value	142·2	120 to 200	151·2
Total alcohols, calculated as geraniol . . *per cent.*	42·7	35 to 70	45·0
Solubility in 70 per cent. alcohol	Insoluble	Soluble in 2 to 3 vols.	Insoluble

The sample was valued at 10*s.* 6*d.* per lb. in London (August 1918).

This oil corresponds to the "insoluble" type of commercial ginger-grass oil; and although it does not contain a high percentage of total alcohols, it was regarded by essential oil merchants as quite normal in character and odour.

Vetiver Oil from India

In September 1917 a sample of vetiver oil prepared in the United Provinces was received at the Imperial Institute. It consisted of a clear dark-brown viscous oil having the characteristic persistent odour of vetiver oil.

The results of chemical examination of this oil, in comparison with vetiver oil distilled in Europe and vetiver oil from Réunion, are shown in the following table:

	Present sample.	Vetiver oil distilled in Europe.	Vetiver oil from Réunion.
Specific gravity at 15°/15° C.	1·001	1·015 to 1·04	0·990 to 1·020
Optical rotation α_D	(oil too dark)	+25° to +37°	+22° to +37°
Refractive index $n_{D}20°$	1·522	1·522 to 1·527	1·515 to 1·527
Acid value	6·0	27 to 65	4·5 to 17
Ester value	16·8	9·8 to 23	5 to 26
Solubility in 80 per cent. alcohol at 15° C.	Soluble in 1·5 vol. with cloudiness on further dilution	Soluble in 1 to 2 vols. with cloudiness sometimes on further dilution	Soluble in 1 to 2 vols. with cloudiness on further dilution

The present sample was regarded as being worth 60*s.* per lb. in London (August 1918). In July 1914 Réunion vetiver oil was quoted at 29*s.* to 30*s.* per lb.

The physical and chemical constants of this sample agree with those of Réunion vetiver oil, but essential oil merchants to whom the oil was submitted stated that it differed somewhat in odour from the Réunion oil. The sample was of satisfactory quality, and would realise a good price in the London market.

INDIAN PATCHOULI OIL

THE patchouli oil of commerce is derived from two species of *Pogostemon* (Natural Order, Labiatæ), Singapore patchouli being obtained from *P. Patchouli*, Pellet. (*P. Cablin*, Benth.), which occurs in a wild state in the Philippines and is cultivated chiefly in the Straits Settlements and Penang, whilst Java patchouli is yielded by *P. Heyneanus*, Benth. The latter species is found both wild and cultivated in Western and Central India, and appears to be the only one met with in India (see *Kew Bulletin*, 1908, p. 80 ; *Perfumery and Essential Oil Record*, 1913, **4**, 369, 418).

Samples of patchouli oil were received from the United Provinces for examination in 1917 and 1919. The first consisted of a clear dark-brown oil with an intense, characteristic odour. The second oil was cloudy, owing to the presence of moisture. After filtration it was clear yellowish brown, and had the characteristic odour of patchouli oil.

The oils furnished the following results on examination, which are compared with the figures recorded for commercial samples of Singapore patchouli oil:

	No. 1.	No. 2.	Singapore patchouli oil. Imported oil.	Singapore patchouli oil. Distilled in Europe from imported leaves.
Specific gravity at 15°/15°C.	0·992	0·998	0·955 to 0·980	0·965 to 0·995
Optical rotation $\alpha_{D20°}$.	—[1]	−77°	−44° to −62°	−50° to −68°
Refractive index $n_{D20°}$.	1·513	1·515	1·506 to 1·513	1·506 to 1·513
Acid value . . .	3·3	1·0	0 to 1	1 to 5
Ester value . . .	4·4	5·3	1·5 to 8	2 to 12
Solubility in 90 per cent. alcohol at 15° C.	Soluble in 0·3 vol.	Soluble in 0·3 vol.	Soluble in 3 to 10 vols.	Mostly soluble in 1 to 2 vols.

[1] *Oil too dark to allow the optical rotation to be determined.*

It will be seen that the specific gravity and optical rotation of the Indian oil are slightly higher than those recorded for the commercial oil obtained from Singapore, whilst the refractive index is also above the average of that of the latter oil. Both samples were superior to Singapore oil as regards their solubility in 90 per cent. alcohol.

The first sample of oil was valued at from £5 to £6 2*s*. 6*d*. per lb., c.i.f., in August 1918. Specimens of the second oil were forwarded to several firms who had expressed interest in the earlier sample, and their observations are summarised below:

One firm stated that they would be glad to consider business in the oil if they could be informed definitely as to the quantities available and date of shipment. They mentioned that they had bought considerable quantities of patchouli oil from the Straits Settlements at 55*s*. per lb. and under, c.i.f. London. They were of opinion that the best form of packing for the oil would be in bottles of 20 or 21 ozs., guaranteed contents, and twelve bottles to a case. The bottles should be packed with great care in straw envelopes, and the cases should be strong.

A second firm stated that the sample exhibited the characters of a normal Indian oil, and was of very good quality. They added that they would be interested in such an oil and enquired whether it was likely to be produced regularly.

A third firm considered the oil to be of good commercial

quality, and had no doubt that consignments could be sold in the United Kingdom and in America. They stated that the market for patchouli oil is very irregular, prices fluctuating very considerably as the result of the spasmodic demand and at present being about 65*s.* to 70*s.* per lb. The firm would be prepared to handle shipments of the oil, charging the sellers a commission of 3¾ per cent.

A fourth firm reported that the oil was of excellent quality and odour, and valued it at about 60*s.* to 70*s.* per lb. They were, however, not prepared to make any immediate offer, as they had sufficient stock on hand for their own purposes. This firm considered that the best form of packing would be in tins, and preferably small tins of about 10 lb. each, as in the case of leakage the loss is thereby minimised. The tins should be packed in cases containing, say, 60 lb. net, which would be a convenient size to handle.

A fifth firm expressed considerable interest in the oil, but thought the smell a little unusual. Before considering the purchase of consignments of the oil the firm desired to have further particulars, and they suggested that it would be best if the producers made offers to them.

The results indicate that this patchouli oil is of good quality, and that consignments of similar oil would be saleable if offered at a suitable price. The lower prices of the second sample, quoted in the foregoing paragraphs, as compared with the earlier sample, are due to a fall in the market price of patchouli oil at the time the sample was examined (March 1920). The names and addresses of the firms referred to above have been furnished to the Government of the United Provinces, with a view to their being put in touch with the producers of the oil in India.

A NEW SOURCE OF THYMOL

HITHERTO almost the whole commercial supply of the antiseptic thymol has been obtained from ajowan oil, derived from the seeds of an Indian plant (*Carum copticum*, Benth.). The possibility of obtaining thymol from the oil of *Ocimum viride*, Willd., was discussed in this BULLETIN (1917, **15**, 322), and an account was there given of the

results of examination of a sample of the oil produced experimentally in Seychelles.

Last year a consignment of the oil was forwarded to the Imperial Institute by the Curator of the Botanic Station, Seychelles, for sale to a firm of manufacturing chemists, who desired to carry out trials with the oil on a practical scale in order to ascertain its value for the manufacture of thymol.

The oil was of pale-brown colour, and was examined at the Imperial Institute with the following results, which are compared with the constants of the previous samples of *Ocimum viride* oil received from Seychelles:

	Present sample.	Previous samples. (1)	(2)
Specific gravity at 15°/15° C.	0·910	0·942	0·924
Optical rotation α_D	+ 0·75°	+ 1·08°	+ 0·6°
Refractive index $n_{D20°}$	1·497	—	—
Phenols . . . . *per cent.*	37	62	52

The phenols present in the oil consisted almost entirely of thymol.

The greater part of the consignment was sold to the manufacturing chemists, who reported that thymol is easily isolated from the oil. The price paid, viz. 10*s*. per lb., must be regarded as very satisfactory, as the oil contained only 37 per cent. of thymol, whereas the sample reported on by the Imperial Institute in 1917 contained 52 per cent. of thymol, and was valued at only 5*s*. to 6*s*. per lb. The increase in the value of the oil is due to the advance which has since taken place in the market price of thymol.

In this connection, however, it must be observed that not only was the percentage of thymol in the oil lower than in the previous samples, but that the yield of oil in the present instance (2 litres per ton of leaves) was somewhat less than 0·2 per cent., as compared with yields of 0·5 and 0·45 per cent. respectively in the case of the samples received at the Imperial Institute in 1916 and 1917. It was pointed out to the authorities in Seychelles that it is of importance that it should be ascertained whether this low yield of oil was due to faulty distillation, or whether it was due to the stage of growth or condition

of the leaves or to any preliminary treatment to which they might have been subjected.

With regard to the decreased percentage of thymol in the oil, it is desirable to determine whether the percentage depends to any large extent on the stage at which the leaves are gathered. It was therefore suggested that distillation trials should be made with leaves collected at various stages of growth and specimens of the oil forwarded to the Imperial Institute for examination. In each case the yield of the oil from the leaves should be carefully recorded. It should be possible in this way to determine the conditions for obtaining the largest yield of oil containing a maximum of thymol.

SPEARMINT FROM SOUTH AFRICA

Spearmint (*Mentha longifolia*) collected in the Somerset East district of the Cape Province was received at the Imperial Institute in July 1918.

The sample consisted of entire dried plants, excepting the roots, and had the characteristic odour of spearmint. It was composed of leaves (with small stems attached) 40 per cent., and loose stalks 60 per cent.

The stalks were found on examination to be practically free from volatile oil. On distillation with steam the leaves, with the small stems attached, yielded 2·4 per cent. of volatile oil, equivalent to a yield of 0·98 per cent. from the entire original sample as received.

The oil was mobile and colourless, and had the strong characteristic odour and taste of spearmint oil. It was submitted to chemical examination with the results shown in the following table, which includes for comparison figures recorded for English and American spearmint oil :

	Present sample.	English spearmint oil.	American spearmint oil.
Specific gravity at 15°/15° C.	0·947	0·926 to 0·935	0·920 to 0·940
Optical rotation α_D	− 47·6°	− 39° to − 52°	− 30° to − 53°
Refractive index n_D	1·4925	—	1·4800 to 1·4890
Ketones (estimated by sulphite method) as carvone *per cent.*	70	30 to 48	35 to 66

The ketones present consisted largely or entirely of carvone.

The oil from this sample of *Mentha longifolia* is similar in character to English and American spearmint oil derived from *Mentha spicata*, Huds., or *Mentha viridis*, L., but it contains a higher percentage of ketones than these oils. In the latter respect it corresponds with Austrian spearmint oil, which is stated to contain up to 72 per cent. of carvone. German spearmint oil is sometimes distilled from *Mentha longifolia*, Huds., var. *undulata*, Briq.

The quantity of oil obtained was too small for commercial valuation, but it may be stated that the market price of spearmint oil appears to be subject to considerable variation, even under normal conditions. The price in the United Kingdom varied in 1911 from 8*s*. to 18*s*. per lb., and rose in 1913 to 24*s*. per lb.; in August 1918 it was as much as 35*s*. per lb. The price appears never to drop below about 7*s*. per lb.

There is little doubt that the oil of *Mentha longifolia* from South Africa would be saleable as spearmint oil, but it would be desirable to have a larger sample for submission to essential oil merchants. In order to obtain sufficient oil for this purpose a request has been made for a consignment of about 1 cwt. of the leaves, or a sample of 1 to 2 lb. of the oil if this can be distilled in South Africa.

In the fresh condition *Mentha spicata* and *Mentha viridis* are stated to yield 0·18 to 0·3 per cent. of volatile oil, but no information appears to be on record as to the yield from the dried plants.

The bulk of the spearmint oil of commerce is consumed in the United States, where it is largely employed for confectionery purposes and in the manufacture of chewing gum.

SPECIAL ARTICLE

COTTON GROWING IN THE BELGIAN CONGO[1]

By Edmond Leplae

Director-General of Agriculture in the Belgian Colonial Office.

It seems likely that Central Africa will some day supply the European markets with a much larger and better crop of cotton than was expected. The Uganda Protectorate and Nyasaland are already among the cotton-producing countries, their soils and climates having proved quite suitable to the growing of a very useful type of cotton.

The purpose of this note is to show that conditions favourable to cotton cultivation extend also to the centre of Africa, and cover a large tract of country.

Transport facilities by river and rail throughout the Belgian Congo have been considerably improved during the war, and several cotton-producing districts are now shipping a few hundred tons of cotton to Antwerp and the cotton-mills of Belgium.

Cotton growing appears to be a valuable asset for the Belgian Colony, the quality of the Congo cotton being quite satisfactory. Many samples have been displayed in the Colonial Exhibition at Antwerp (May–September, 1920).

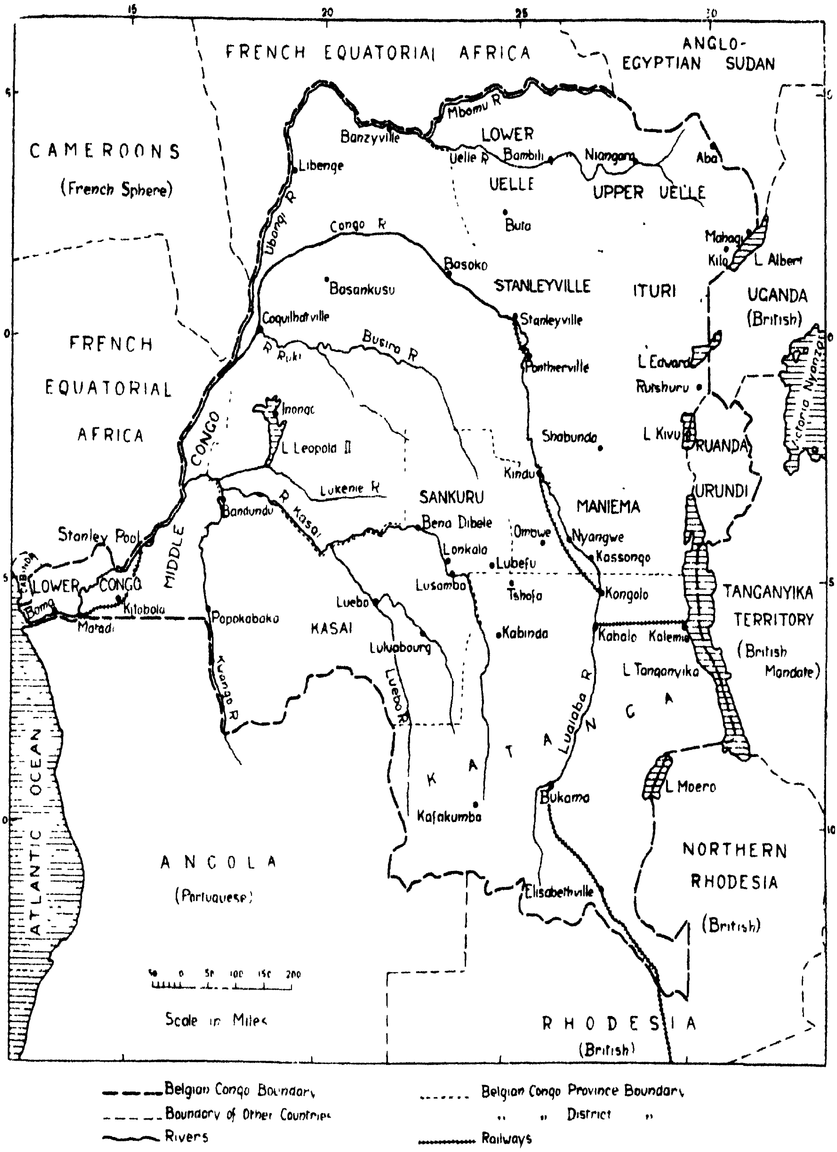
Cotton-growing Experiments in the Congo Free State

The Government of the Congo Free State tried several times to introduce cotton in the Lower Congo.

These trials met with no practical success. Lower Congo is not adapted for this kind of crop : rains are very irregular and can never be depended upon to supply the necessary moisture at the right moment. The annual

[1] A general account of native agriculture in the Belgian Congo, and particulars of the various experiment stations in the Colony, are given in an article by M. E. Leplae in this Bulletin (1914, 12, 60).

SKETCH MAP OF BELGIAN CONGO.



To illustrate the article on Cotton Growing in the Belgian Congo, by M. E. Leplae, in the Bulletin of the Imperial Institute, 1920, Vol. XVIII, No. 3.

rainfall will barely reach 30 inches in a year of drought, and may be as much as 70 inches in the succeeding year.

More detrimental still are the extraordinary delays that occur in the advent of the rainy season. While rain is supposed to start in October–November, it has been known to begin as late as February, giving only three months of rain instead of six, and upsetting every planting scheme made by the would-be cotton growers.

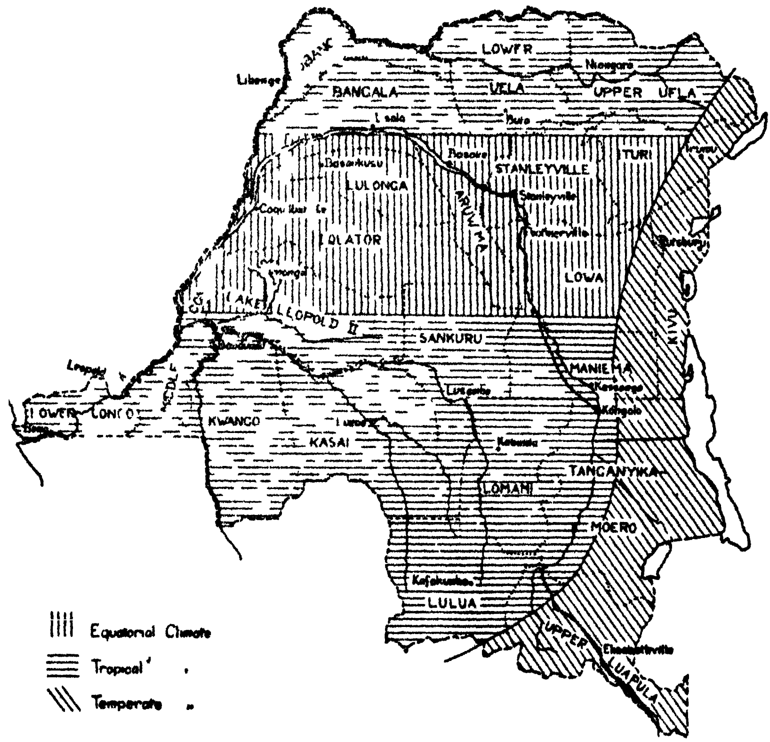


Fig 1 —Belgian Congo, Climatic Regions

The Lower Congo District is very similar as regards rainfall to the more arid parts of German East Africa; the amount of rain has an average of about 44 inches, being much lower than the average rainfall of Central Congo (cf. tables on pp. 354 and 393).

Notwithstanding these adverse conditions, several attempts were made under the Congo Free State Government to introduce cotton among the crops grown by settlers or natives. American, Egyptian and Peruvian

Rainfall in the Lower Congo District

	Boma.				Congo da Lemba.				Kitobola.		
	1916.	1917.	1918.	1919.	1916.	1917.	1918.	1919.	1916.	1917.	1918.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
January	128·8	177·5	17·0	13·0	294·3	274·0	124·8	117·9	96·7	124·3	72·3
February	167·7	95·0	57·0	2·5	177·5	134·0	173·0	47·4	101·3	88·6	48·6
March	142·9	239·0	64·0	37·1	261·4	112·2	36·9	28·6	258·7	105·7	174·4
April	213·8	149·5	243·0	20·0	222·3	173·9	346·0	120·6	181·9	179·5	294·8
May	9·1	101·0	—	5·5	51·8	154·5	34·7	16·2	147·9	87·2	100·2
June	—	—	—	—	—	—	—	—	—	—	—
July	—	—	4·0	—	2·0	—	8·2	—	—	—	—
August	—	8·5	—	10·2	—	4·2	4·4	6·1	—	7·3	—
September	8·2	3·3	13·5	20·0	12·5	9·9	5·8	2·2	10·0	34·4	1·8
October	125·4	10·0	18·7	44·4	200·7	10·1	19·7	57·7	276·2	44·2	131·4
November	278·0	4·0	164·5	219·7	346·5	15·6	88·1	243·8	262·0	59·7	267·1
December	66·5	73·0	228·5	196·4	198·5	83·8	138·4	285·1	74·4	44·2	173·9
Total mm.	1,140·4	860·8	810·2	1,168·8	1,767·5	972·2	980·0	925·6	1,409·1	775·1	1,264·5
,, inches	43½	34	32½	46¼	70¾	39	39	37	56⅓	31	50⅓

cotton seed were tried in the State Agricultural Stations, but gave no definite practical results.

Cotton-growing Experiments under the Belgian Government

The Congo Colony was taken over by Belgium in 1908, and in the following year a new and more thorough experiment in cotton cultivation was conducted under the superintendence of J. Claessens, Agricultural Engineer, who formerly held a cotton farm in Oklahoma (U.S.A.). This expert concluded that cotton growing in the Lower Congo could never be an economical proposition, except possibly if carried out by the native farmers.

Acting on this sound advice, the Government directed some of its agriculturists to distribute cotton seed, and information about planting, cultivation and picking, among the native villages in the Lower and Middle Congo districts, the Government promising to buy the crop from the natives at a remunerative price. The results of this new departure were, however, disappointing, owing to the uncertain rainfall and the carelessness of the natives.

The cotton-growing experiments were then taken in hand by the new Agricultural Department, organised in 1910, which had started operations in the Congo by introducing Para rubber in the Government Plantations in place of Funtumia and rubber vines.

Having carefully perused the reports on the former cotton trials, we were led to the conclusion that more extensive and more methodical experiments were needed, that cotton growing should be tried in the Upper or Central Congo districts, and that the experiments should be conducted by a cotton expert who was fully acquainted with the American system of cotton cultivation and also conversant with the conditions of African agriculture.

With the approval of the Colonial Minister, M. J. Renkin, the Agricultural Department wrote to Mr. Hutton, Chairman of the British Cotton Growing Association, whose advice was asked and very readily granted, as to the selection of a reliable cotton expert. Acting on Mr. Hutton's advice, our Department secured the service of Mr. E.

Fisher, from Memphis (U.S.A.), formerly employed by the Gold Coast Colony, and in charge of cotton-growing experiments in the Volta River district. Mr. Fisher has been at work in the Congo since 1913, and has given ample proof of his technical skill: the encouraging results obtained in the Belgian Congo are for the greater part due to the untiring activity of this American expert.

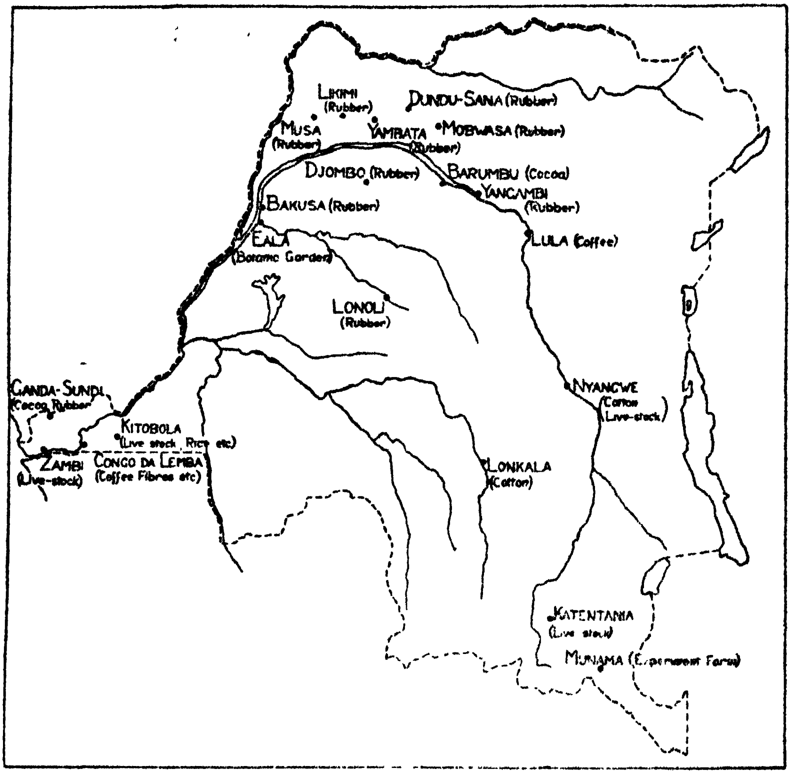


Fig. 2.—Belgian Congo, Agricultural Experimental Stations.

COTTON EXPERIMENTS AT THE KITOBOLA FARM

The cotton grown in the central parts of the Congo has to be carried by river and rail over a distance of 600–1,200 miles before reaching Matadi, whence it is shipped to Europe. As this inland transport materially increases the initial cost, we first asked Mr. Fisher to try cotton cultivation once more in the Lower Congo, the most favourable place in this district being the Government Experimental Farm at Kitobola, within 120 miles of the shipping port of Matadi.

This farm lies in the Lukuga lowlands, has rich alluvial soil, a fine herd of 200 cross-bred cattle, a concrete dam and 150 acres of land under irrigation. A good cart-road connects the farm with the railway station at Tumba, nine miles distant.

Farm manure, working oxen and seeds were available and also animal-driven machinery for operating the cotton gins. Fine crops of irrigated and dry rice and some sugar-cane were grown on this farm.

About 50 acres of cotton were planted in 1913 without irrigation, and several quite satisfactory fields were obtained. But the unreliability of the rainfall was proved in a decisive manner, as the rains were very irregular and scanty, and large tracts of cotton in the unirrigated fields were a total loss.

Consequently any further experiments in cotton growing in the Lower Congo were given up, and Mr. Fisher was instructed to start up river and plant cotton in the Maniema district.

The varieties of cotton grown at Kitobola and the details of the cultivation of this new crop were described as follows in Mr. Fisher's official report. The particulars given will, it is hoped, prove interesting to everyone who tries to plant cotton in Central Africa.

" *Land for Cotton Growing.*—I chose, with the assistance of the Farm Manager, about 20 hectares (50 acres), located in different parts of the farm, to start my cotton-growing experiments on.

" About half this land had been or was then in actual cultivation, having been planted with maize, sweet potatoes, etc.

" The land planted with maize gave considerable trouble during the cultivating period, owing to the grass and weeds, which came up abundantly all through the season. Especially troublesome was a nut-grass with which parts of the land were infested, and which it is almost impossible to keep down during the rainy season.

" The land that had formerly been planted with sweet potatoes gave far less trouble, as the rank-growing potato vines had almost entirely subdued grass and weed growth, and it was only necessary to pull up the potato vines which for some time grew up from the tubers left in the ground.

" The remainder of the land, although it had once been

in cultivation, was lying fallow at the time of its being taken over, and was covered with grass and weeds to such an extent that they had to be mowed down before the land could be ploughed. Naturally the ground was full of seeds from this grass and weeds, which made the after-cultivation occasionally somewhat laborious.

"While all the land chosen was not the most fertile on the station, it was of good average fertility, a few small areas being exceedingly fertile. It also contained considerable land which had had the top-soil washed off by heavy rains; but being enclosed in the area chosen, it had to be cultivated to keep down the obnoxious grass and weeds.

"From the beginning, it was decided that regular field trials would be the most serviceable to show the average crop that could be produced with average labour and cultivation.

"It would have been possible to increase considerably the average yield per hectare by more intensive cultivation and garden trials, but such trials would have been of small value in testing crops that later on have to be planted over larger areas with such labour as we have here. For the selection of seed and the selection of specific plants, the so-called garden trials are of great value.

"*Ploughing.*—As mentioned above, Kitobola possesses a great advantage in the herd of cattle which makes it possible to plough and prepare the land thoroughly before planting (Plate VII, fig. 1).

"This last season was rather unfavourable for the proper preparation of the soil, as the extremely dry weather retarded the operations and made the work harder for the cattle and implements, whilst some of the land broke up into big clods, entailing extra labour to reduce the soil to a fine tilth. The drought several times rendered ploughing altogether impossible, and the work had to wait until sufficient rain fell to soften the earth. For this reason also, some of the plantings were made later than originally intended, as the land could not be prepared in time.

"On account of the extreme dryness, the grass which was not completely covered by the plough had to be taken up by hand, piled and burned. Otherwise it was liable to go on growing after the next rain, and even if it had not grown again, it would have made the cultivation of the cotton more laborious and exacting.

"Ploughing, if done properly, is far superior to breaking and preparing the land with hoes before planting. It is very doubtful if the work of preparing the land could have been done by hand labour this year, as only a few

PLATE VII

Fig. 1.—Ploughing cotton fields on the Kitobola farm, Belgian Congo.

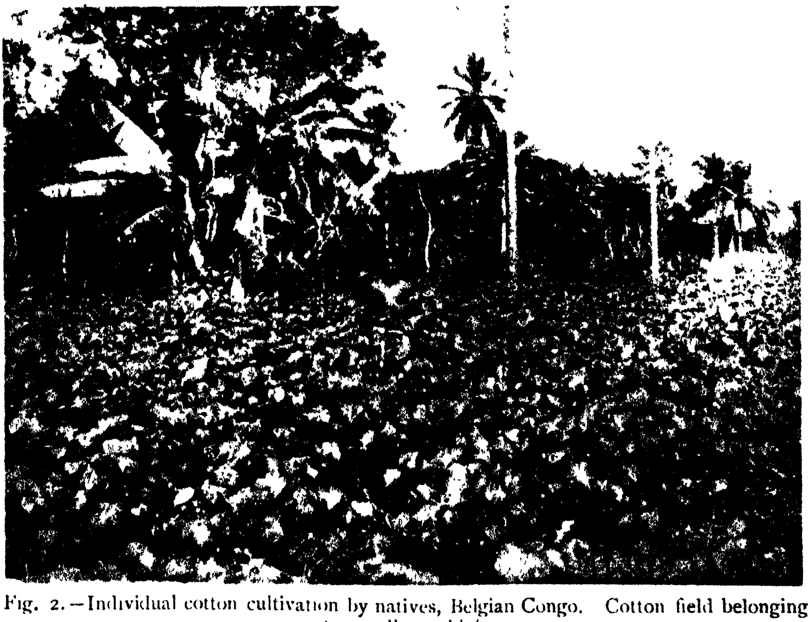


Fig. 2.—Individual cotton cultivation by natives, Belgian Congo. Cotton field belonging to a village chief.

heavy soaking rains fell at long intervals, so that the ground was never thoroughly softened.

" Under these circumstances, the preparation of the ground could not be considered satisfactory. As the grass and grass-roots turned under by the plough failed to rot, because of the dry weather, many young growing plants failed to take root properly, and were therefore stunted or even killed.

" *Seed for Planting.*—The seeds for planting were obtained through the kindness of the British Cotton Growing Association of Manchester, England, and consisted of the following varieties :

" Allen.—American long staple.
" Sunflower.—American long staple.
" Nyasaland.—Originally an American long staple, grown and acclimatised for several years in Nyasaland.
" Triumph Big Boll.—American Upland short staple.
" Simpkins' Early Prolific.—American Upland short staple.
" Abassi.—Egyptian white long staple.
" Sakellaridis.—Egyptian cream long staple.

" While the seeds of these different varieties were somewhat mixed, the plants were mostly true to type as regards plant growth, foliage, shape and size of bolls, length of growing period, percentage of lint, etc. The length of staple and the yield naturally vary in varieties grown under a different climate and different conditions from those obtaining in the land of origin.

" *Germination Trials.*—The trials carried out for testing the germinating power of the seed were on the whole satisfactory and gave results ranging from 77 to 95 per cent.

" *Climate and Rainfall.*—After considering the meteorological statistics for the last five years, which showed an annual average rainfall of about 1,300 mm. (54 inches) with two more or less defined rainy seasons, it was at first decided to start planting about December 15 and continue until about January 15, making two or more different plantings of each of the varieties of seed from ten to fifteen days apart. But as January is usually a rather well-defined dry month at Kitobola, it was finally decided to start planting on December 1 and continue until January 10, to give the seed ample time and opportunity to germinate before the ground became too dry. The past season has been unusually abnormal, December being the driest month of the rainy season, with only 40 mm. of

rainfall, but November and January were not much better, with 72 and 76 mm. respectively.

"As a whole, the season was unfavourable for thorough and definite trials. While the rainfall was exceedingly moderate for the whole season, it would have been quite sufficient if it had been more evenly distributed. Towards the end of the rainy season, fogs and cloudy days were prevalent, and the sunshine which was needed for ripening the fruit failed for days at a time. Occasional rains, with subsequent sunshine, would have been far preferable.

"*Insect Pests.*—Some of the seed that was planted during the dry weather, and lay in the ground too long, was eaten by white ants and other insects. Seed that germinates properly is hardly ever attacked by them, but if, owing to unfavourable weather, the seed cannot germinate and push above the ground, a great many are eaten, and sometimes the whole planting is totally destroyed.

"*Shedding of Bolls.*—Next to leaf-curl, the shedding of bolls was the most serious trouble that had to be contended with. Very little can be done to remedy it. Several of the varieties planted suffered considerable loss, which was mostly caused by sudden changes from extreme dry to wet weather, or vice versa. A few of the bolls were thrown away after having been attacked and injured by various insects, but this damage was not very noticeable."

The average yields given by the varieties of cotton in the Kitobola trials were as follows :

—	Date of planting.	Yield of seed cotton		Yield of lint.		
		Kilos per hectare	*Pounds per acre*	*Kilos per hectare*	*Pounds per acre*	*Per cent.*
Nyasaland	Dec. 2	479·4	421·8	135·0	118·8	28·2
„	Jan 3	112·0	98·5	31·5	27·7	
Allen's long staple. .	Dec. 3	562·0	494·5	168·0	148·3	30·0
„ „ „ . .	Jan 6	530·0	466·4	159·0	139·9	
„ „ „ . .	Feb. 28	52·0	45·7	15·6	13·7	
Simpkins' short staple .	Dec. 5	830·0	730·4	284·5	250·3	34·5
„ „ „ .	Jan. 10	1,031·0	907·2	353·8	311·1	
Triumph long staple .	Dec. 23	1,216·0	1,070·0	419·4	369·0	
„ „ „ .	Jan. 16	182·0	160·1	63·0	55·9	
„ „ „ .	Feb. 28	257·5	226·6	88·9	78·2	
Sunflower long staple .	Dec. 29	453·3	398·9	128·7	113·2	28·4
„ „ „ .	Jan. 17	66·5	58·5	19·0	16·7	
„ „ „ .	Mar. 2	139·4	122·3	39·6	34·8	
Abassi, Egyptian . .	Dec. 29	950·0	836·0	269·0	236·7	28·3
„ „ . .	Jan. 12	545·0	479·6	154·0	135·5	
Sakellaridis, Egyptian .	Dec. 30	1,222·5	1,086·8	366·5	322·5	30·0
„ „ .	Jan. 12	585·7	515·4	175·7	154·0	
Native greenseed . .	Dec. 6	1,050·0	924·0	294·0	258·7	28
„ blackseed . .	„ 6	880·0	774·4	246·4	216·8	

On the conclusion of the cotton trials at the Kitobola farm, Mr. Fisher was asked to proceed to Stanleyville and Nyangwe, in Upper Congo, where the climate and the native population appeared to be much better adapted to successful cultivation.

First Year of Cotton Growing at Nyangwe (Maniema) (1914—1915)

The Government Experimental Farm at Nyangwe (Maniema) has several hundred acres of sandy and rather poor soil, exhausted by repeated cultivation during about twenty years.

Nyangwe, on the Lualaba or Congo River, is the historical village discovered by Livingstone in 1869, at that time held by the Arab slave dealers, and where the British missionary was an unwilling witness to the shooting and drowning of 400 native women. This town was taken by storm by the Belgians under Commandant Dhanis in 1892 during the war against the slave traders.

Its site was first used as a military training camp, and later as a Government Cattle Farm. The herd numbered about 500 head of cattle. The climate was held to be suitable for cotton, the rainfall being regular, with about 52 inches of rain and only two months of dry weather.

The first planting of cotton covered 55 acres, the same varieties being grown as were planted in 1913 at Kitobola.

The results of these experiments were satisfactory, showing that the natural conditions of Nyangwe were suitable for this new crop.

Mr. Fisher wrote as follows in his Report dated Nyangwe, October 1915; his remarks are very interesting because they give a detailed description of the factors affecting the growing of cotton in Central Africa:

Soil

" Nyangwe is situated on the right or east bank of the Lualaba, somewhat south of the 4th degree south latitude. Near the river the land is rolling, with rather deep and sometimes steep depressions between the elevations, and is covered with numerous anthills.

" Further inland the terrain becomes more and more

flat, with the depressions less pronounced; the descents become more gradual and the anthills decrease perceptibly both in number and in size.

"Nearly all the land consists of a sandy loam with a clay subsoil, easy to plough after the first ploughing and easy to cultivate. It is of an average fertility, except in a few places, where sand is predominant or where there are steep declivities from which all the surface soil has been washed by heavy rains.

"The lowlands between the ridges, sometimes of quite large extent, contain the best soil, but these could not be cultivated, as they were covered with water during the rainy season. On the whole they are all easy to drain, having a good gradient, and a beginning has been made with the level nearest the station by digging a canal in the lowest part of it.

"On several short excursions into the interior it was found that nearly all the land is of about the same quality, and large areas could be put under cultivation with very little trouble.

"Further inland the plateaux or tablelands extend in size and it is not difficult to find almost level plains of several hundred hectares in extent, with hardly any anthills on them, the few that are encountered being of such slight elevation as to be hardly noticeable. On these short trips were also found numerous cotton plants around villages, or sites of former villages. All these plants were of the native varieties, either kidney or free seed. To judge from the size of some of the plants, they must have been from fifteen to twenty years old, and were still yielding cotton, but of such poor quality that it would be almost unsaleable in the European markets. No doubt these varieties could be improved by cultivation, but at best native cottons yield far less and are of a poorer quality than the exotic varieties.

Ploughing

"The kraal of working oxen contained about fifty head of very healthy-looking cattle. If they had all been trained to work, it would have been an easy matter to prepare the land required for the cotton-growing experiments very quickly. But it was found that only about sixteen oxen were trained to work, and some of these were not very well trained. The number being so small, the same oxen had to work day after day. The consequence was, that starting work at 7 o'clock in the morning, the animals often gave out before 10 o'clock and refused to go farther. They

had to work in the mornings, and were sent to the pastures in the afternoon. The work therefore progressed rather slowly, and much of the cotton had to be planted considerably later than was at first intended.

"Oxen that have to work regularly day after day need special feeding. It is not sufficient after working them half a day to turn them loose on the pastures, as they cannot pick up sufficient nourishment on the sometimes rather scanty pastures in the short afternoon, which is the hottest part of the day. As there is plenty of good land here all around the station, the growing of feeding-stuffs for the working cattle would not be difficult.

"The work was heavy for the oxen. The grass and weeds were from 3 to 7 feet high, and thickly covered the soil. This grass had to be ploughed under, a rather risky proceeding for the future of the cotton crop, but there existed no other means of getting rid of it. It was too green to burn, as it had been raining for two months.

"A mowing machine would have been of immense service in cutting the grass ahead of the ploughs. This also would have made the work easier for the cattle. To cut the grass by hand labour was entirely out of the question as being too slow and costly.

"The grass was therefore ploughed under as well as could possibly be done. Because of its length it was impossible to cover it completely, and the uncovered tops sticking out of the ground naturally kept on growing. Before preparing the land for planting, these grass tops had to be cut by hand, as the small harrows we have here were unable to cover or tear them up. The labour expended on this work was considerable.

"Fortunately the Nyassi grass,[1] with which most of the land was covered, was not very difficult to kill and gave very little trouble afterwards where the land had been ploughed properly.

"On account of having to cover the grass as much as possible, the ground had to be ploughed rather more deeply than is advisable on new land, but this could not be helped. The ploughs were of various descriptions, and were old and dull and greatly worn in their running gear.

"Two good harrows were made which, although rather too light for new land, did excellent work in preparing the land for planting. They saved a large amount of hand labour which otherwise would have been necessary to break

[1] "Nyassi" or "nyazi" is the usual designation of *Imperata arundinacea*, Cyrillo (= *I. cylindrica*, Linn.), in the eastern parts of the Congo. The same grass is called "nianga" in the Western Congo.

the clods and level the ground. Since then another harrow, somewhat larger and heavier, has been received.

"Experimental farms should be provided with the best of implements and materials. It is difficult enough to introduce new crops on new lands and in untried climates without having to contend with worn-out and prehistoric tools, implements and machines.

Seed for Planting

"The seed used for planting was obtained from the previous season's planting at Kitobola, and all the varieties that were planted there were experimented with here also, as follows:

"Allen.—American long staple.
"Sunflower.—American long staple.
"Nyasaland.—Originally American long staple, for years acclimatised in Nyasaland.
"Triumph Big Boll.—American medium to short staple.
"Simpkins' Early Prolific.—American short staple.
"Abassi.—Egyptian long staple.
"Sakellaridis.—Egyptian long staple.
"Peruvian White Long Staple, received from Paraguay.
"Greenseed.—Native African short staple.
"Blackseed.—Native African short staple.

"As at Kitobola, the seed was somewhat mixed and not a single variety was altogether pure. But the resulting plants were generally true to the different types as regards plant growth, leaves, shape and size of bolls, length of growing season, approximate percentage of lint, etc.

Germination Trials

"Before planting, the usual trials as to the germinating power of the seeds were carried out, as on the percentage of good sound seeds depends the number of seeds that should be planted.

"While it is a good plan to plant sufficient seed in each place to ensure a good regular stand, it is sometimes a drawback to plant too many, as if for any reason it is not possible to thin them out in time, the plants grow up spindly and weak and do not make healthy, robust plants. As a rule the seed resulting from cotton grown in the tropics is not of such good quality as that grown

in a temperate zone, so great care should always be exercised before planting, and the seed should be carefully examined to avoid the possible production of a bad stand and consequent loss.

"Much damage to the seeds is caused by the redbugs, which enter the bolls as they commence to open, and suck the juices of the still unripe and soft seed, thereby destroying their germinating power. Other seeds are faulty on account of unripe or damaged capsules opening before the seeds are mature; such damage may be caused either by insects or disease.

"The best way to examine the seeds as to their germinating power is to plant a certain number in a small box and water them regularly. If not planted too deeply, and if watered regularly and kept in a warm sunny place, nearly all the seeds should germinate on the fifth or sixth day. Seeds germinating after the eighth day should be regarded with suspicion.

Climate and Rainfall

"It was unfortunate that no records of the rainfall had been kept at Nyangwe for any length of time. A regular rainfall record kept for about five years is of great advantage. Not only does it give one an idea of the average rainfall to be expected during the season, but it also shows the average limits and duration of the so-called intermediate short dry season, which generally makes its appearance in the middle of the rainy season.

"The records being insufficient—they had only been kept one year—to give one a general insight, the planting was done on the strength of the Kitobola records, which lies in nearly the same latitude, and this supposition was found to be about correct, the only difference found so far being that the real dry season here begins somewhat later and is not quite so extremely dry as at Kitobola.

"Although the total amount of rainfall (1,234·6 mm. = 49·3 in. from July 1, 1914, to June 30, 1915) was more than sufficient for the successful cultivation of a cotton crop, the rains were somewhat unevenly distributed. Several times excessive rains of from 40 to 100 mm. fell, followed by comparatively long dry spells.

"These heavy rains as a rule do more harm than good. They descend with such force that they pack the surface of the ground and do not enter the soil, all the water running off, washing up plants and covering others with silt. Slow rains of from 10 to 20 mm. at regular intervals would be the most desirable.

"The details of the rainfall from July 1914 to June 30, 1915, are shown in the following table:

Daily and Monthly Rainfall during the season July 1, 1914, to June 30, 1915, in millimetres

Date.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.
1	—	—	—	—	3·5	—	—	—	0·5	7·2	—	—
2	—	—	12·5	—	—	11·3	67·0	—	—	—	—	—
3	—	—	—	1·4	35·0	—	4·5	—	—	—	—	1·4
4	—	—	—	—	50·5	12·3	—	—	—	—	—	—
5	—	30·5	3·5	—	—	4·0	—	—	14·5	—	—	—
6	—	—	—	—	—	—	13·5	7·0	11·3	—	0·3	—
7	—	—	—	—	8·5	—	—	—	—	9·2	—	—
8	—	4·8	7·0	13·7	—	—	—	—	—	—	—	7·6
9	—	—	—	—	—	—	—	—	—	—	1·6	11·4
10	—	—	—	—	—	—	—	—	—	2·9	7·4	—
11	—	—	—	38·5	—	—	—	—	—	6·5	—	—
12	—	—	—	—	—	2·2	14·5	—	—	5·7	1·1	—
13	—	—	—	12·5	17·5	—	4·5	—	—	—	18·4	—
14	—	—	—	—	34·0	57·5	—	—	—	—	—	—
15	—	—	—	—	—	—	—	—	—	—	1·8	—
16	—	—	—	—	26·0	—	—	1·5	—	—	—	—
17	—	—	—	—	—	—	—	—	—	—	—	—
18	—	—	—	2·5	—	—	—	—	—	4·0	—	—
19	—	—	—	—	—	5·0	5·0	5·6	54·8	—	—	—
20	4·0	8·0	5·0	—	31·5	—	—	4·4	—	—	—	—
21	—	—	7·0	—	—	10·0	—	—	32·4	—	—	—
22	—	—	23·0	—	9·1	—	4·7	—	—	100·6	—	—
23	—	—	—	—	4·0	—	—	—	—	—	—	—
24	—	5·7	—	24·2	23·0	4·0	—	—	—	—	—	—
25	—	—	—	—	4·0	34·5	—	—	—	4·0	—	—
26	—	—	2·0	—	—	—	—	—	11·5	17·0	—	—
27	5·7	—	—	5·0	22·0	—	—	54·3	—	—	—	—
28	—	—	11·5	—	—	—	—	—	7·1	—	—	—
29	4·5	—	—	29·0	—	—	—	—	—	—	—	—
30	—	—	—	—	—	8·5	—	—	9·4	—	—	—
31	—	—	—	10·0	—	—	9·1	—	—	—	—	—
Total, mm.	14·2	49·0	71·5	136·8	268·6	149·3	122·8	72·8	141·5	157·1	30·6	20·4
„ inches	0·57	1·9	2·8	5·4	10·7	5·9	4·9	2·9	5·6	6·2	1·2	0·8
Number of rainy days	3	4	8	9	13	10	8	5	8	9	6	3

Total this season (July 1914 to June 1915): 1,234·6 mm. (49·3 in.).
Total last season from Oct. 1, 1913, to Sept. 30, 1914: 1,282·9 mm. (51·3 in.).

Time to Plant

"The time to plant cotton depends entirely on the rainy seasons, and should be so arranged that the first bolls commence to mature at the beginning of the dry season. On well-cultivated land sufficient moisture will remain in the ground to enable the full crop to mature even in the case of the slowly maturing varieties.

"*Native cottons*, if the best results are to be obtained, must be planted at the beginning of the first rainy season, say in October, as they are of exceedingly slow growth, and it takes the plants from six to seven months before they even commence to arrive at maturity, afterwards yielding for about three months.

"The *Egyptian and American long-stapled cottons* should

be planted fully four months before the end of the rainy season, as they require that length of time to develop and ripen their first bolls. They should be planted in December.

" The *American short-stapled varieties,* which require a shorter time to arrive at their full development, can be planted between December 15 and February 1, according to their precocity. There is considerable difference in the length of time required by the different short-stapled varieties to reach full development, and a knowledge of the duration of their period of growth is an advantage. For instance, of the two short-stapled varieties grown here, the 'Triumph Big Boll' takes four months to become fully developed, after which it requires another four months of a comparatively dry season to ripen all its fruit. 'Simpkins' Early Prolific,' however, the other short-stapled variety grown here, will arrive at maturity in from three to three and a half months, and will ripen nearly all its fruit in the succeeding two months. Each has its advantages and disadvantages, which will be mentioned later under their respective headings.

Planting

" The proper distance to plant depends largely on the quality of the soil and the varieties to be planted.

" The average for most of the American varieties on lands of average fertility is about 4 feet (1·20 m.) between the rows and from 12 to 18 inches (35 to 50 cm.) in the rows.

" On poor sandy land the distances both ways can be somewhat reduced, and on very strong, fertile soils they may have to be somewhat increased.

" The short-stapled varieties, of small growth such as Simpkins', can be planted in rows one metre distant from each other by 30 to 35 cm. in the rows.

" The number of seeds to be planted depends on their quality, which should be carefully determined before planting. The object is to have a regular stand at the above-mentioned distances, with one strong vigorous plant in each place. Where the germination trials give a good result of about 80 per cent. and over, five seeds are sufficient; if not so good, more should be employed accordingly. They are planted at a depth of from 25 to 44 mm., shallower if the season be wet, and deeper if dry; but as the weather is sometimes variable, a medium depth is generally chosen.

" The Egyptian varieties require about the same distances as the American long-stapled varieties, although in Egypt itself they are planted at considerably smaller

distances. The reason for this is, that while the American long-stapled varieties generally produce plants with spreading limbs, covered with fruit from the bottom limbs upwards and close to the main stalk, the limbs of the Egyptian varieties, especially if planted close together, grow more upright and produce most of their fruit high up from the ground and away from the main stalk.

"Nearly all the native African varieties produce a large bush and must therefore be planted at correspondingly greater distances both ways, say from 1·80 to 2 metres between the rows and from 75 to 90 cm. in the rows, much also depending on the quality of the soil. The depth at which the seed should be planted is the same for all varieties.

"Where the natural drainage of the fields is good, it is preferable to plant on a flat terrain, as thereby much less ground is exposed to the influence of sun and strong drying winds ; where the drainage is not good and there is danger of water standing over the field for any length of time after heavy rains, it is best to plant on ridges, as the young plants especially are injured by water standing around them.

Cultivation

"If the ground is in good and mellow condition, containing sufficient warmth and moisture, the seeds will germinate in from five to eight days.

"If planted with a planter, which performs the work more regularly and plants all the seed at the same depth, nearly all the seeds will push above ground on the same day ; if planted by hand, as has to be done here, it is impossible to plant evenly, and the seeds come up over a period of from two to three and even four days. While this is of no special consequence, it would be preferable to have all the seeds germinate at the same time.

"As soon as the third and fourth leaves appear, about three weeks after planting, the plants should be thinned out to one only in each place, care always being taken to leave only the strongest and healthiest plants. The soil should be loosened around the plants and all weeds and grass kept down.

"After another three or four weeks, when the plants have reached a sufficient height and have had another hoeing and weeding, it is perhaps preferable to hill them slightly, that is to draw up some soil around them, as this strengthens them against high winds.

"Where the stand is regular and the plants are growing well, three cultivations during the growing season should

be sufficient, as after the third cultivation the plants should be large enough to shade the ground and prevent the growth of grass and weeds.

" At Nyangwe it was necessary to cultivate oftener, as the stand was very bad at the beginning, which left numerous large bare places on which grass and weeds had a good chance to grow.

" Much replanting had to be done. As a rule it does not pay to replant, as the resulting plants are a month or more later than the plants from the original first planting ; they are shaded and kept back by the larger plants and hardly ever reach full development.

" If the stand is very bad and there is sufficient time for the growing season, and plenty of seed is available, it is preferable to destroy the old plants and replant the whole field. In this case the plants grow better and more evenly and are easier to cultivate.

" This system could not be followed at Nyangwe this season, as the time was already too far advanced and there was a scarcity of seed.

" A faulty stand may be due to (1) bad seed, (2) unfavourable weather conditions at the time of germination, *e.g.* either drought or excessively heavy rains, and (3) inefficient preparation of the soil.

" At Nyangwe drought and heavy rains necessitated some replanting. A field of over two hectares in extent, just as germination was taking place, was deluged by a heavy rain of 67 mm., which packed the ground so hard that it was impossible for the plants to push through. This field had to be entirely replanted.

" Towards the end of the planting season excessively dry weather caused some large gaps, especially on the anthills, which need plenty of rain for the germination of the seed.

" But the main cause of the imperfect stand was the late preparation of the ground. The ploughing was done too late for the new land, and, as mentioned previously, the long, tough grass standing on the land, which we had no means of cutting, had to be turned under as well as was possible. The season being somewhat dry this grass failed to rot, although there is no likelihood that it would have rotted sufficiently to improve matters if it had rained every day. It was too late to replough the land with small ploughs, even if we had had the necessary cattle, as it was time to plant.

" As was feared, the unrotted grass in the ground prevented a great many seeds from germinating and even caused many of the plants to die after they had germinated

and reached a good size. The roots of the cotton plant are very sensitive, and as soon as they strike a hole in the ground and lose contact with the soil the plant dries up and dies. Mainly for that reason several plots had to be replanted four times, until it was too late to plant again and the seed gave out.

"The result is that a careful estimate of each plot showed that the gaps amounted on the average to 36 per cent. Most of this is to be attributed to the new terrain and the late turning under of the high grass and weeds.

Insect Pests

"On the whole, insects, with the exception of white ants, have not done much damage to the cotton. Some seeds, slow in germinating, were destroyed by white ants and other insects, but this happens throughout the tropics and has to be taken into account when planting.

"Seeds that germinate in the proper time and grow vigorously are seldom attacked. If owing to unfavourable weather conditions or other causes, such as faulty preparation of the soil, the seeds fail to germinate quickly, they are very liable to be attacked and destroyed, and sometimes such inroads are made that the whole has to be planted over again.

"White ants caused considerable trouble, not only in the fields, but also in the warehouse, where special care had to be taken to combat their depredations. In the field they ate some seeds and destroyed a few of the growing plants by boring into the stalks, but these plants had generally received some prior injury before being attacked. At any rate the damage so done was slight. But later on they destroyed a good many open bolls, which for some reason had become detached from the stalks and fallen to the ground. The damage thus caused was quite noticeable.

"It is a curious fact that in the 'Triumph' fields a good many limbs were laden so heavily with the large bolls that limbs, leaves, green bolls and open bolls were lying flat on the ground; but as long as the green or even open bolls, which had been open for a long time and were perfectly dry, were attached to the living plants, they were not attacked.

"In the warehouse, which was built of mudbricks and wood and covered with grass, the damage done would have been immense if proper precautions had not been taken in time.

"The ants were worst on the new lands, which had been ploughed the first time, not so bad on land which had been

ploughed once before, and almost unnoticeable on lands which had been in cultivation for a number of years. This naturally leads to the supposition that continuous cultivation has a tendency to drive them away.

"Grasshoppers were very few and did no damage, although the fact of the new grass lands being taken in led to the supposition that they would be plentiful, as such lands are generally an ideal breeding-place for them and harbour great numbers.

"Plant-lice did a little damage in places. They are generally only noticed when the crop for some reason, such as drought or other unfavourable condition, is backward. As long as the plants are healthy and in good growing condition, they can do no harm.

"Leaf-curl is most probably caused by cicadas, as they are always present when this malady appears, and as far as I know there is no other known cause for this disease. These cicadas are about the same size as the plant-lice, and can be easily mistaken for them. But while the plant-lice are sluggish in their movements, and have no wings, the cicadas are winged, and upon being disturbed move and fly about very quickly. Their presence can easily be detected in the early morning by striking the plants with a stick, when they can be seen flying from plant to plant. In colour they are greenish yellow, and, like the leaf-lice, attack the under-side of the leaves. They cause the leaves to curl at the edges, the older leaves generally curling upwards, while the young and tender ones curl down, dry up, decay and fall off. Affected plants, if young, should be pulled up and burned. In the case of older plants an arsenical poison could be used to advantage, but young tender cotton plants are generally injuriously affected by such preparations.

"The leaf-curl attacked the two plots of native cotton only, which almost joined each other, a strip 10 metres wide of pois cajans (*Cajanus indicus*) having been planted between the two. The native varieties as a rule are the most resistant to all unfavourable conditions, and were thought to be immune from this disease.

"Bollworms, of which a few were noticed, did no considerable damage. They feed on the inside of the growing bolls, and therefore cannot be reached by poison. No really effective remedy that could be used to advantage exists.

"Leaf-eating insects were noticed occasionally, but occurred in such small numbers that they caused no damage.

"Leaf-rolling insects were more numerous, but the

damage done was not very great, only a plant here and there being attacked and generally destroyed.

"Cotton Stainers or Redbugs (*Oxycarenus*) have stained some of the cotton, besides destroying the vitality of some seed, but they were in much smaller numbers here than in any other parts of Africa that I am acquainted with, and the damage done was not great.

Fungoid Diseases

"Anthracnose or Boll-rot very often attacks the young plants soon after they have germinated, if the spores have been introduced with the seed, and kills them, leaving a gap in the row. At Kitobola last season we had very little of this disease, and that little only in the Allen variety, which is very susceptible to it. Here the disease showed itself in four fields of both Egyptian varieties, which were planted on new land; it appeared mainly in the form of boll-rot, reducing the yield on these fields by fully two-thirds. The seeds obtained from these fields are without doubt infected with the disease, and it will be unsafe to plant them for fear of spreading the disease over a larger area. To kill the spores that remain in the soil, rotation of crops should be carried on for at least one year—that is, maize or some other crop should be planted on the affected lands—but this will hardly be possible here for the present.

"There are certain varieties of cotton, such as Simpkins', which are very resistant to this malady and are hardly affected by it.

"Underground fungus and root-rot did not make their appearance.

"Mildew and rust affected a few of the plants, after they had matured, but did no considerable damage.

"Shedding of bolls always occurs to some extent owing to various causes, most of which cannot be prevented. Cultivation at the wrong time and by unsuitable methods has been known to cause almost the whole crop to be shed, but there is no danger of this happening here. If the plants are overloaded with fruit, a certain amount of it is shed, but this hardly ever causes any serious damage. More serious damage is caused sometimes by unfavourable weather conditions, such as sudden changes from long, dry, hot spells to cool and wet weather or vice versa, or either long-continued wet or dry weather. From this cause considerable fruit was lost here this season. Occasionally insect attacks cause many bolls to be shed, but such damage was not very noticeable.

Description of Varieties grown at Nyangwe in 1914–15

" *Nyasaland.*—Originally an American long-stapled cotton (the name has been lost, but it is most probably Allen) which has been cultivated successfully for several years in Nyasaland, and with varying success in several other parts of tropical Africa. It has all the characteristics, as to plant growth, shape of leaves and bolls, etc., of the American long-stapled varieties.

" At Kitobola this variety did not do well as regards yield, and although the quality of the cotton produced here is somewhat better, the yield is again disappointing, the very poor stand and the condition of the land on which it was planted partly accounting for the small crop. The land was new grass-land, which, as mentioned previously, does not yield its best the first year, even under most favourable conditions, whilst the preparation of the land was faulty. It will be given another trial on a small scale next season. Seed selection is especially necessary with this variety and would without doubt have given good results, but owing to lack of the necessary storage facilities and sacks this could not be done this season.

" *Allen Long Staple.*—One of the best American long-stapled varieties, but yielding rather indifferently in the tropics, and at best giving a cotton of far inferior quality to that produced in America from the same variety. As in the case of the Nyasaland cotton, this variety was planted on new grass-land, subject to the same unfavourable conditions; but in spite of the missing stand of nearly 20 per cent. its yield exceeded that given by the former variety, and it produced a far better grade of lint. As regards seed selection, the same should be said of the Allen as of the Nyasaland cotton. In fact all the cottons grown here would have been improved by selection, or at least would not have suffered any degeneration.

" *Sunflower Long Staple.* — Another well-known American long-stapled variety, which is regarded in America as being almost equal to the Allen. It did not yield nearly as well here as the Allen, and the staple also is of inferior quality. As to the difference in yield, it was planted on a particularly badly prepared plot of new grass-land, which even after repeated replantings still had gaps amounting to 40 per cent. of the whole. It is expected that with seed selection it will give a greatly increased yield and a cotton of superior quality.

" The reason these long-stapled cottons should be further experimented with is that the plants appear strong and healthy, and have proved very hardy in spite of all the unfavourable conditions.

" Exceptional plants of the above three varieties have given very large yields of cotton of rather good grade.

" These three varieties were planted in December, quite early enough to reach their full development before the end of the rainy season. It took them about four and a half months to arrive at maturity. But on account of the bad stand, they all had to be replanted four times; some of the replanted seed grew very well, but the plants never reached their full development.

" *Sakellaridis and Abassi.*—The two Egyptian varieties, Sakellaridis and Abassi, were each planted in three different fields and at three different times.

" The two earlier plantings of both varieties, which were made on new grass-lands, were attacked late in the growing season by anthracnose, which mainly showed itself in the form of boll-rot. This resulted in a greatly reduced yield of fibre which was of poor quality.

" Two of the fields had to be entirely replanted because shortly after planting a heavy rain packed the ground so hard that the germinating seed could not push through.

" The last two fields were planted towards the end of January on land which had formerly been in cultivation. This was too late for these varieties, which require about four and a half months to arrive at full maturity before the dry season sets in.

" These last fields showed no sign of anthracnose, and this led to the supposition that the new land was the cause of the disease in the other fields of the same varieties. Even in these fields, however, the cotton produced was far from being of as good a quality as the same varieties produced at Kitobola last season.

" As at Kitobola, the Sakellaridis proved the better of the two in yield as well as in quality. The cause of the deterioration in quality is not known, but it must probably be mainly attributed to degeneration. These long-stapled varieties degenerate very quickly, far more quickly than the short-stapled cottons, unless a rigorous seed selection is followed. The climate here is about the same as at Kitobola, and although the soil is somewhat lighter than in the valley of the Lukunga, there is not much difference in the actual fertility. The Kitobola soils would probably last longer without being fertilised.

" *Simpkins' Early Prolific.*—This is a cotton of a rather short but very strong staple. In fact its shortness of staple is its only disadvantage. Otherwise it yields well, is very resistant to drought, fungoid diseases and insect pests, and has a very short growing and ripening season.

"It will reach full development in three to three and a half months after being planted, and afterwards will ripen most of its fruit in the two months following. This makes it very suitable for planting late in the season, when it is too late to plant varieties with a longer growing season or when for some cause the land cannot be prepared in time. This would be about the only variety which would have any chance of success nearer the equator, where the dry season is very short.

"It produces a low, bushy, strong plant, with very strong limbs, which are rarely bent down to the ground by the weight of the bolls.

"Five fields of different sizes were planted at various times. The two earlier fields were planted on new lands; this resulted in a bad stand for the reasons mentioned previously. Later on two small fields were planted on land which had been in cultivation before. Although these fields also had a poor stand, the plants grew and yielded remarkably well. The last field was planted too late, because it was impossible to prepare the land sooner. Here the stand was very bad on account of drought, and the plants that did grow did not have time to reach full development before the end of the rainy season. So far as can be seen, Simpkins' is one of the varieties best adapted to this locality, but, with all its advantages, the disadvantage of its short fibre is great, and it would be preferable, if possible, to produce cottons of better grade and staple.

"*Triumph Big Boll.*—This is, as its name denotes, a variety with exceedingly large bolls. Its staple is considerably better than that of Simpkins', and might well be called medium. Its advantages are: (1) it yields very well, (2) it requires far fewer bolls to make a kilo. of cotton than most of the other varieties, and owing to the large size of the bolls a much greater quantity of seed-cotton can be gathered daily, thus reducing the cost of picking, a very important item in the cultivation of cotton, and (3) the percentage of lint to seed is very high, viz. 35 per cent. and over.

"Now as to its disadvantages. It has a longer growing season and a considerably longer ripening season than Simpkins'. In fact, after reaching full development, it requires about four months to ripen all its bolls. These two items, however, are not disadvantages in a locality with well-defined and lengthy rainy and dry seasons. In these circumstances, the rainy season continues long enough to enable the planting to be done in ample time for the plants to reach maturity before its close, and the dry

season is also long enough for all the bolls to mature without being too much injured by wet weather.

"A serious disadvantage of the Triumph variety is that as the large bolls are exceedingly heavy, the limbs cannot sustain their weight and they bend to the ground, so that many of the bolls rest on the soil, where they accumulate dirt and are subject to the attacks of insects and rodents.

"Three fields of different sizes were planted at different times. The stand on all these fields was worse than that of any of the other varieties planted here, but this was not due to the seeds being of an inferior quality. The seeds of the first-planted field were destroyed by heavy rain, the second field was of a rather inferior fertility, and both these fields were on new land. The third field suffered considerably from drought at the time of planting; but in spite of the very bad stand, all the fields yielded very well, and if the stand had been normal would have given an enormous yield. The first two fields were replanted, but the seeds gave out and replanting could not be continued.

"Triumph also produced a rather low, strong, bushy and spreading plant, but as already mentioned the limbs are not strong enough to sustain the weight of the heavy bolls. It is not nearly so resistant to drought and diseases as Simpkins', but as a rule it gives a higher yield, and the cotton is of considerably better grade and staple. It seems to be very well adapted to this locality, and is a far better cotton than Simpkins'. Seed of the Triumph variety will be distributed to the natives here as long as it lasts, but if further seed is called for, Simpkins' will have to be distributed.

"*Greenseed and Blackseed.*—Both these native varieties gave excellent results at Kitobola last season, viz. 1,050 and 880 kilos. per hectare respectively. This is a remarkable yield for native cottons. It is true the areas planted were very small, 2 and 1¼ ares respectively, but the land was not the most fertile, and the crop received only the usual field cultivation. Both varieties grew very well here with few missing plants. When about fully developed, leaf-curl attacked the Greenseed and spread rapidly to the Blackseed variety, although a band 10 metres wide of pigeon pea, which had reached a height of 3 metres, was planted between the two plots. The leaves turned up at the edges, dried up and fell off, leaving only the bare stalks, and naturally arresting all further fruiting. Afterwards, the plants produced new leaves, but it was too late in the season to recover the loss.

" These native varieties are generally the most resistant to drought, diseases, insect pests and other unfavourable conditions, and are generally thought to be immune. If the leaf-curl disease had been noticed in time, it is doubtful if any effective remedy could have been applied, because of the enormous size of the plants. The yield was naturally very small. The cotton of these native varieties is generally very short and woolly.

" Both will be given a further trial next season.

" *Peruvian White Long Staple.*—Seeds of this variety were received from Paraguay. The quantity of the seeds being very small, only about 10 ares were planted. This was done in the latter part of January, at least one month too late, as this variety, like the Egyptian cottons which it much resembles, requires about 4½ months to arrive at full maturity. Still, it yielded well and gave very good fibre.

"In plant growth, leaves, fruit, etc., it greatly resembles the Egyptian varieties, but the plant is more robust, and the limbs are heavier and more spreading, requiring on fertile soils to be planted at larger distances than the average. The plants reached a height of about 2½ metres, and acquired their full plant growth, but would have yielded more fruit if planted earlier. The bolls, like those of the Egyptian cotton, are small and three-celled.

" As this variety seems promising, a larger area will be planted next season.

" *Peruvian Red Short Staple.*—Two rows were planted with seed of this variety, but not one seed germinated. A few seeds were received at Kitobola very late last season; these were planted late in March, and the resulting plants, on account of the following dry weather, only reached a height of about 60 cm. A few bolls opened prematurely, but the seeds resulting from these immature bolls did not germinate.

" Details of the results obtained with the different varieties are given in the table on page 378.

Summary

" 1. At Nyangwe is an immense terrain, which seems to be suitable for the growing of cotton, and has the advantage of well-defined and lengthy rainy and dry seasons. Being a savannah country, the land can be prepared with small labour and cost.

" 2. If cotton growing is taken up as a native industry, and the soil becomes worn out from continuous cultivation, new lands can be taken up with very little additional labour, although it is a well-known fact that new grasslands do not yield their best during the first season.

Name of variety.	Date of planting.	Area of plots.	Total yield of seed-cotton.	Average yield of seed-cotton.		Total yield of lint.	Percentage of missing plants.	Possible yield of seed-cotton if stand had been normal.	
		Hectares.	*Kilos.*	*Kilos. per hectare.*	*lb. per acre.*	*Kilos.*		*Kilos. per hectare.*	*lb. per acre.*
Simpkins' I . .	Jan. 4	1·74	981	564	496·3	317	25	752	661·7
,, II . .	,, 16	1·41	1,350	957	842·1	460	23	1,243	1,093·8
,, III . .	,, 25	0·30	293	977	859·7	95	19	1,206	1,061·2
,, IV . .	Feb. 1	0·54	608	1,126	990·8	198	22	1,444	1,270·0
,, V . .	Mar. 3–6	3·30	1,615	489	432·5	—	67	1,482	1,304·1
Triumph I . .	Dec. 30	2·36	1,347	571	502·4	470	57	1,328	1,168·6
,, II . .	Jan. 15	0·92	641	697	613·3	223	69	2,249	1,979·1
,, III . .	Feb. 1	0·41	431	1,051	924·8	—	56	2,390	2,103·2
Sakellaridis I . .	Dec. 15	1·81	571	315	288·2	—	20	394	346·7
,, II . .	Jan. 12	1·69	743	440	384·2	—	29	620	545·6
,, III . .	,, 26	0·45	200	444	387·7	—	40	740	651·2
Abassi I . . .	Dec. 22	1·25	315	250	220·0	—	16	298	262·2
,, II . . .	Jan. 14	1·12	376	336	295·6	—	26	454	399·5
,, III . . .	Jan. 26	0·40	215	538	473·4	—	31	780	686·4
Allen. . . .	Dec. 18	0·84	520	620	545·6	—	19	766	612·8
Sunflower . . .	,, 23	1·24	581	470	413·6	—	40	784	689·9
Nyasaland . . .	,, 19	0·73	350	480	422·4	—	32	706	621·2
Peruvian White . .	Jan. 23	0·11	126	1,146	1,008·4	—	36	1,791	1,576·6
Greenseed native .	Dec. 3	0·81	92	114	100·3	—	5	120	105·6
Blackseed native .	,, 5	0·81	140	173	152·2	—	6	195	171·6
		22·25	11,495						

Total area of cotton fields : 22·25 hectares = 55 acres.
Total yield of seed-cotton : 11½ tons.
Average yield of seed-cotton per hectare : 516 kilos.
Average yield of seed-cotton per acre : 454 lb.

"3. Where, as at Nyangwe station, the soil can be fertilised every year or two with stable manure, it is not necessary to let it lie fallow to recuperate, although occasional rotation of crops would be of great benefit.

"4. Rotation of crops not only helps the soil, but destroys numerous insect pests and fungoid diseases, which might become injurious if the same crops were planted year after year on the same land.

"5. As at Kitobola last season, only field trials were carried out to ascertain what could be done with average native labour and average cultivation.

"6. The native in the neighbourhood of Nyangwe is an excellent agriculturist, as can readily be seen by the well-kept state of the farms of tobacco, rice and other agricultural products. If he would expend the same time, care and labour on the cultivation of cotton, there is not the least doubt that he would make a success of it, and it would certainly be more remunerative to him for the time and labour expended than the other crops mentioned, of which the local market prices are very low.

"7. If a native cotton-growing industry is established here, a seed farm, where continuous seed-selection can be carried on, will be almost a necessity. Otherwise new seed

will have to be imported every three or four years. Cotton degenerates very quickly in the tropics, if left to itself, and it would be impossible to make a native understand the value of seed-selection or, even if he understood it, to induce him to practise it.

" 8. For the successful cultivation of cotton, irrigation is unnecessary in a district with such well-defined and lengthy rainy and dry seasons.

" 9. The best time for planting the long-stapled varieties seems to be December, and for the short-stapled cottons January. Simpkins' can probably be planted with good chance of success as late as February 15. Native cottons should be planted in October.

" 10. Leaf-curl almost totally destroyed the crop of the two native varieties planted here. Anthracnose attacked several fields of the Egyptian varieties which had been planted on new lands. Otherwise very little damage was done by insects and fungoid diseases.

" 11. It is perhaps appropriate to say here that for experimental farms the best implements and machines should be provided. It is difficult enough to experiment with new crops on fresh lands and in untried climates without being handicapped by makeshift appliances.

" 12. The experiments here have definitely shown that soil and climate are very well adapted to the cultivation of cotton. No definite decision has yet been reached as to the varieties to be preferred, but the main aim should be to grow the best possible. All the better-grade varieties here have suffered setbacks this season, which are by no means decisive, and which with further experimentation might be entirely overcome or at least to a great degree mitigated."

Second Year of Cotton Growing at Nyangwe (1915–16)

First Trial of Cotton as a Native-grown Crop

As the ploughing and planting of cotton had been abnormally late in 1914–15, owing to Mr. Fisher being delayed on his way from Kitobola to Nyangwe, the first really normal trials were those of 1915–16.

An area of 135 acres was planted with cotton. Mr. Fisher reports as follows:

Rotation

" Although at present most of these lands are of only average or even somewhat inferior fertility, taking the

district as a whole, they can be greatly improved by continuous, proper cultivation, occasional application of stable manure, of which there is an abundance, and a proper system of rotation of crops. If so handled and treated, the land can be worked continuously year after year, instead of having to lie fallow and becoming again covered with grass and weeds.

Land for Cotton

"As was anticipated, the lands that were in cultivation last year and previous years gave far better results than the new grass-lands cultivated this year for the first time. The latter have been burned over yearly and trampled by cattle continually, and it requires some time to get them into a proper state of cultivation so that they will give a maximum yield. The first year is always the worst, because the plant-food ingredients in the soil do not dissolve in sufficient time and quantities to benefit fully the crop.

"Again, these new lands are very deficient in humus owing to the annual fires, which cause the ground after rains to pack very quickly and solidly to the detriment of the young tender plants.

Ploughing

"At the beginning of the season the lack of sufficient rain retarded ploughing considerably. Later, when the rains commenced, the grass and weeds grew so rapidly that the work of ploughing proceeded rather more slowly than could have been desired.

"Efforts were made to cut the long grass ahead of the plough by hand, but this is generally an unsatisfactory proceeding, as machetes and hoes are the only implements available. Scythe blades do not exist here, and in any case they would probably be too dangerous to be handled by a native.

"A mowing machine is badly needed, for this grass question is an annual and continous one. No ploughing can be done before the beginning of the rainy season, and then the grass commences to grow so quickly that it is impossible for the plough to keep pace with it.

"All the old land that had been in cultivation for a year or more ploughed excellently, as well as considerable portions of the new land that could be ploughed before the grass became too high.

Seed for Planting

" Most of the seed planted resulted from the crop grown here last year, and, owing to the very favourable planting season, with regular and light rains, they germinated and grew spendidly. Even on the anthills, where it is sometimes extremely difficult to obtain a regular stand, the plants came up with scarcely any blanks. The same cannot be said of the seed that was shipped here from Europe and arrived just at the beginning of the planting season. Although this seed was perfectly sound and germinated fairly well, the resulting plants were backward and the yield was far below that from the fields planted with the acclimatised seed.

Germination Trials

" The seed here gave a fairly good germination percentage, that is for the tropics, namely from 65 to 85 per cent. The seed which arrived from Europe at the beginning of the planting season also gave a fair germination percentage, but the resulting plants, especially those on the new land, were weakly and yielded relatively little, probably owing to the seed being too old.

Climate and Rainfall

" The climate during the year was seasonable, there were no really cool spells cold enough to check the continued growth of the young cotton, but the rainfall at a critical period of the plants' growth was seriously deficient. The average rainfall for the two previous years, *i.e.* as long as any records had been kept at Nyangwe, was 1,258·25 mm. per year, but this season it amounted to only 1,008·7 mm. (40·3 in.), a reduction of 250 mm. This amount would have been quite sufficient if the rainfall had been properly distributed.

" The rainy season started somewhat late, but there was ample time to prepare the cotton lands properly before the arrival of the regular planting season. Although there were some heavy rains, they fell in such a manner that scarcely any damage was caused to the seed in the ground or to the seedlings, which is somewhat unusual. The whole of the planting season was ideal for the proper germination of the seed and the growth of the young plants.

" About the middle of February the usual short dry season arrived and lasted three weeks, but the growing plants were in such a condition that no harm was done.

" After a good rain at the end of the three weeks another dry season of about five weeks' duration set in, which caused

such serious damage that the fields never entirely recovered from it, and the prospect of a large yield was destroyed. Maize, rice and ground nuts planted by the natives in the neighbourhood also suffered severely.

"Details of the rainfall during the year July 1, 1915, to June 30, 1916, are given in the following table :

Rainfall for Season July 1, 1915, to June 30, 1916, in Millimetres

Date.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.
1	—	—	—	—	1·4	50·5	—	23·5	6·6	—	—	—
2	—	—	—	—	7·7	—	1·2	2·1	0·2	—	—	—
3	—	—	—	—	0·4	3·7	—	8·8	—	0·7	46·7	—
4	—	—	—	—	1·5	0·9	2·6	4·7	—	—	1·5	—
5	—	—	—	7·8	—	—	—	0·4	—	—	—	—
6	—	—	24·5	6·3	—	—	7·5	—	—	—	—	—
7	—	—	—	—	—	1·0	8·0	0·9	1·4	—	27·7	—
8	1·2	—	—	—	10·3	—	14·3	—	—	—	5·2	—
9	—	—	—	—	—	15·3	—	1·5	—	—	2·4	—
10	—	—	24·2	—	—	—	—	—	4·7	5·1	3·0	—
11	—	—	—	—	—	20·7	—	—	30·3	—	0·2	—
12	—	—	—	—	1·4	—	—	—	—	—	—	—
13	—	—	6·8	—	—	0·7	—	—	0·4	—	—	—
14	—	—	—	19·4	5·2	28·7	8·7	—	—	—	11·6	—
15	—	—	—	—	—	—	—	—	—	15·5	—	—
16	—	—	—	8·5	—	—	61·1	39·4	0·9	2·0	—	—
17	—	3·8	—	—	—	—	—	—	—	8·8	—	—
18	—	—	—	—	—	4·2	1·5	—	—	14·0	—	—
19	—	0·5	13·0	—	25·7	—	17·1	—	—	20·2	—	—
20	—	—	—	—	—	—	0·3	15·2	6·9	0·6	—	—
21	—	—	—	—	—	0·4	—	—	1·3	—	—	2·9
22	—	—	—	22·8	—	—	35·0	—	—	—	—	—
23	—	—	—	0·10	33·0	—	—	10·1	—	44·4	—	—
24	—	—	—	—	—	—	34·2	—	3·0	—	—	—
25	—	—	—	0·1	—	3·7	—	—	—	2·7	—	—
26	—	—	1·6	—	10·5	0·3	13·8	—	—	—	—	—
27	—	4·3	—	—	0·7	0·6	—	—	—	0·3	—	—
28	—	—	—	0·8	—	—	1·0	—	1·4	0·6	—	—
29	—	—	—	—	1·2	21·7	—	—	—	2·5	—	—
30	—	—	—	3·9	—	—	—	—	—	—	—	—
31	—	—	—	—	—	7·3	—	—	—	—	—	—
Total mm.	1·2	8·6	70·1	70·6	109·0	159·7	206·3	106·6	57·1	118·3	98·3	2·9
„ inches	0·05	0·34	2·8	2·8	4·4	6·4	8·3	4·3	2·3	4·7	3·8	0·11
Number of rainy days	1	3	5	9	12	15	14	10	11	13	8	1

Total for season: 1,008·7 mm. (40·3 in.).
Average for two previous years: 1,258·2 mm. (50·3 in.).

Cultivation

"On account of the seasonable weather no trouble was experienced this season in keeping the fields clean and the plants in proper growing condition. Nearly all the seeds came up between the fifth and eighth day to a regular stand, and the seedlings grew so rapidly that three weeks

after planting they were ready to be thinned out, and the land received its first thorough cultivation. A month later the fields were gone over again—that is, all the grass and weeds were destroyed and the cotton was hilled.

" Scarcely any replanting had to be done, except on the plots planted with the seed which had lately arrived from Europe. As usual all cultivation was done by hand-labour with hoes, as there was no cultivating machinery here.

Gathering

" The gathering of the cotton began in April, unusually early, as owing to the length of the intermediate short dry season in February and March much of the cotton opened prematurely, and it was thought best to gather it as fast as it opened, lest it should be damaged by the rains that were expected.

" As usual the cotton was thoroughly dried before being stored in the warehouse; this is imperative, as green, damp cotton stored away will heat, the fibre will deteriorate and the seeds will lose their germinating power.

Storage

" Great difficulty was experienced in finding sufficient room to store all the cotton. The cotton of the twelve varieties planted here on the farm had to be kept separate, which necessitated considerably more space than if the cotton had all been of the same variety. Moreover, room had to be found for over 25 tons bought from the natives. This difficulty would have been avoided if there had been sufficient gins available to gin the cotton as fast as it was gathered and brought in by the natives.

" A complete iron storehouse has been received here recently, which when properly erected will probably do away with the storage difficulties.

Ginning

"Ginning proceeded very slowly, as there existed here only an old 18-saw Eagle hand-gin, which was imported into the colony thirteen or fourteen years ago. It had several times been worked by inexperienced men, which naturally did not improve it. Moreover, it had been used to gin the 1913–14 crop at Kitobola, and the crop obtained here last season (1914–15). Having to transport it several times over long distances, parts of it had become broken, and although certain repairs were effected, no repairs could be done to the most vital parts of the machine, viz. the saws and the brush.

"The consequence is that the work of ginning the cotton was considerably retarded, and what is worse, owing to the bad condition of the gin, between 3 and 4 per cent. of the lint was lost in the waste. The saws being worn and dull were unable to take off all the cotton from the seed and a considerable quantity of lint passed over with the seed; the brush being worn was unable to clean the lint properly from the saws. It would not even pay to repair this machine, and new machines are urgently needed.

"For tying the bales, native-made rope is being used here, but iron ties would be, if perhaps not cheaper, at any rate more substantial.

Labour

"There was no scarcity of labour of the usual kind. All the population being agricultural, it is not difficult to make them understand the work required. Under continuous supervision they do a fair amount of work, but without constant supervision the work suffers in quality as well as in quantity.

Selection of Seed

"At the beginning of the gathering season some selection of seed was carried out, but the warehouse became so congested that it was impossible to keep the cotton so gathered separate from the other cotton of the same variety.

"While seed-selection is an important factor in keeping up the quality of the cotton, and even improving it, sufficient storage facilities are essential to keep the cotton so selected separate from the ordinary cotton. Again, after seed selection has once been commenced, it must be continued for a number of years, before satisfactory results can be expected. This work can only be entrusted to experienced men.

Distribution of Seed to Natives

"From experiments carried out here last season and at Kitobola the season before, the conclusion was reached that the Triumph variety was the best for distribution to the natives. While Triumph is not a so-called long-stapled cotton, it generally produces a good medium staple, and is sold on the markets of Europe at a considerable premium above American Middling. It is very difficult in the tropics to grow long-stapled cotton that will give uniformly good lint, and moreover the yield is generally too low to be remunerative. There exist numerous other disadvantages in growing long-stapled cotton here.

" Now Triumph, as mentioned above, produces a large yield of cotton of good quality, is easier to gather than any of the other varieties that have been experimented with here, and gins fairly easily. Therefore it was decided to use the seed of the Triumph variety for distribution.

" As the demand for planting seed was greater than the supply of this variety of seed, Simpkins' seed had to be distributed towards the end of the planting season.

Cotton Growing as a Native Industry

" At the beginning of the season serious efforts were made to induce the natives to take up the cultivation of cotton, and these efforts have so far been fairly successful. The natives were shown how to prepare the land for planting, plant the seed, cultivate the fields and gather the cotton.

" It augurs well for the future of this crop that during the first season over twenty-five tons of seed-cotton have already been purchased from the native cultivators. It is a well-known fact that the native is very conservative, and it is difficult to induce him to take up a new and untried crop. Notwithstanding this conservatism over 1,400 kilos. of seed were distributed. Owing to the supply of Triumph seed becoming exhausted towards the end of the planting season and the necessity of distributing seed of the Simpkins' variety, the later cotton brought into the market was more or less mixed. It was considered better to risk this than possibly to make a bad impression by refusing seed to natives who had already prepared their lands for planting.

" Over 900 kilos. of seed of the Triumph variety and considerably over 500 kilos. of the Simpkins' variety were distributed. The last lot of seed distributed did not do so well, as the intermediate dry season commenced before the plants were well established.

" Where the land was prepared, the seed planted and the cotton cultivated according to instructions, the yield was generally excellent, but many of the natives who had prepared their lands well neglected to plant and cultivate properly, and the result was a deficient yield. But there will be no more trouble of this kind, for the natives have seen for themselves that when instructions are followed implicitly the yield is good and the remuneration greater than is possible from any other crops that could be grown on the same land.

" There is not the least doubt that the area of land devoted to cotton will be greatly extended next season.

Already demands for seed have been received from numerous natives who declined altogether to try cotton growing last season or who lived too far away to hear about it.

"There will be enough seed of the Triumph variety available for distribution to meet all demands, which will prevent the cotton from becoming mixed.

"The native has an advantage, in that he has a great choice of terrain, and need plant only the best of his lands, if necessary only a small plot here and there. Another advantage in having small scattered plots is that in case of disease or serious insect attacks, one plot may be attacked, while the others may escape.

Insect Pests

"Insects have done slightly more damage to the cotton this season than in the previous one, but such is to be expected where intensive cotton growing on a larger area is carried out. The total damage caused was not excessive.

"White ants as a rule only attack seeds that are slow in germinating, over-ripe cotton that has fallen to the ground, or plants which have from some cause been injured; but this year a field was found where for ten successive days the ants destroyed healthy plants in excellent growing condition and about one metre high, by completely cutting them off just below the ground. In this way they destroyed about four hundred plants, when suddenly their depredations ceased. The cause of their peculiar action is unknown. It is the first time that I have ever known them to attack cotton plants in such fine growing condition.

"Grasshoppers were very few and did no appreciable damage even on the new lands.

"Plant-lice appeared on the later-planted cotton, but, while in places they retarded its growth to some small extent, they did no serious damage, and although they were always present their depredations were arrested when seasonable weather set in.

"Leaf-curl attacked some of the later-planted Triumph cotton (on new land) and damaged it considerably. A description of the cicadas, to which the disease is supposed to be due, has been given already (see p. 371).

"Boll-worms were considerably more plentiful than in the previous year, but only did noticeable damage in the cotton attacked by the cicadas.

"Leaf-eating insects were always present, but did not serious damage.

" Leaf-rolling insects were also always present, but, with the exception of the destruction of a few plants here and there, did no damage.

" Cotton-stainers or redbugs (*Oxycarenus*) are nearly always present where cotton is grown in the tropics, but they exist here in such comparatively small numbers that their depredations were not excessive.

Fungoid Diseases

" Anthracnose (boll-rot) did no excessive damage, except that it was a principal agent in destroying two hectares of native cotton. This cotton had been attacked the season before by leaf-curl and anthracnose.

" Root-rot did not appear.

" Mildew appeared on some of the last-planted cotton, but too late in the growing season to do any damage.

" Shedding of bolls always occurs and generally causes some noticeable damage. A full description of the disease was given in the last annual report (see p. 372).

Varieties of Cotton

" A full description of most of the varieties has been given in the preceding report (see pp. 373-7).

" *Greenseed and Blackseed.*—Although the native African cottons are considered the most resistant to drought, insect attacks, fungoid diseases and generally unfavourable weather conditions, these two native varieties failed here the previous season, and, although planted this season on entirely new land, they again failed completely. Last season they were attacked by leaf-curl and anthracnose; this season the same diseases were prevalent.

" The cultivation of these varieties will be discontinued; the seed has become infected, whilst the yield is generally very small and the cotton of an inferior quality.

" *Allen Long Staple.*—Although it seemed to suffer more than any of the other long-stapled cottons from the effects of the intermediate short dry season, this variety was the only long-stapled cotton whose yield came up to expectations. It has been planted here for three successive years, has become acclimatised and is well worth experimenting with further.

" *Sunflower Long Staple.*—Although during the whole of the growing season this cotton was in better condition than the Allen, its yield was disappointing and considerably less than that of the latter variety.

" *Peruvian White Long Staple.*—This variety held its own very well during the growing season, but was seriously affected by the long intermediate dry season.

"*Zeidabi*.—A long-stapled cotton of American origin, which has been cultivated and acclimatised in the Sudan. Its parent plant is most probably Sunflower, as it has all the characteristics of this variety. It is well worth while experimenting further with this variety.

"*Sunbeam*.—American Long Staple. The seed was received at the beginning of this season from England. The yield was of fair average for long-stapled cotton, but the ginning results were so poor that it will not be worth while to make further trials with this cotton. The lint outturn was below 25 per cent., which is much too low, even allowing for the fact that the gin was responsible for some loss of fibre.

"*Nyasaland*.—During the first two seasons here this variety did badly, but the results were considerably better this season, and experiments with it on a small scale will be continued.

"*Sakellaridis and Abassi*.—These Egyptian long-stapled varieties, which did well at Kitobola, gave a very poor yield here last season; and although newly imported seed was planted this season, both varieties failed almost completely.

"*Triumph Big Boll*.—This American medium-stapled variety has given the best results of all the cottons tried here during the last three seasons, and it will be exclusively grown by the natives next season. Although it has some disadvantages, it seems to be the most suitable for native cultivation here. It yields well, is easy to gather and gives a fairly good quality of lint. A complete description of this variety and of its advantages and disadvantages is given in the previous annual report (see p. 375).

"*Simpkins' Early Prolific*.—If this variety produced a longer staple it would be the best adapted for native cultivation here, as it is quick growing and quick maturing and one of the most resistant cottons to drought, insect attacks, fungoid diseases and general unfavourable weather conditions, but this does not mean that it is entirely immune. For a full description see p. 374.

Summary

"1. The beginning of the season was most favourable, but a three weeks' intermediate dry season, followed immediately by another of five weeks' duration, did serious damage and reduced the yield considerably.

"2. The native cottons have failed completely this season. Even when at their best, their yield is low and the quality of the fibre is generally inferior. It is not worth while to carry on further experiments with these varieties.

"3. The Egyptian cottons have also been an almost complete failure. In the absence of irrigation and a more suitable climate they will always give disappointing results.

"4. The long-stapled American cottons with very few exceptions can also be eliminated from further experiments. At best their yield is not great and the quality of the fibre is never so good as that of cotton of the same varieties produced in America.

"5. Cotton growing among the natives has given a very fair result for a beginning, and it will certainly be greatly extended next season. Where the cotton was properly planted and cultivated according to instructions, the yield and quality were excellent, and many of the native cultivators were greatly pleased with the remuneration they received for their labour.

"6. Twenty centimes per kilo. of seed-cotton was paid this season, and should be paid another season, but, even at 15 centimes per kilo., cotton that is well cultivated on fairly fertile soil will pay better for the time and labour expended than any other crop that is grown here by natives for the market.

"7. It would be advisable to continue cotton-growing at Nyangwe Station for some years longer to ensure a continual supply of good seed for distribution.

"8. If possible seed-selection should be carried on somewhere in the Colony, but this is not a matter of one year's duration. It must be carried on continuously, and by someone with expert knowledge. Otherwise new seed will have to be imported periodically, which is a disadvantage, as newly imported seed does not do so well as that which has been acclimatised.

"9. Insects, though always present, have done no excessive damage, and the same is true of fungoid diseases.

"10. The cotton seed which is not reserved for planting is fed to cattle, who after becoming used to it, eat it greedily and thrive on it."

Cotton Cultivation in the Sankuru and Kasaï Districts

Government Cotton Farm at Lonkala

The results obtained at Nyangwe and surrounding villages were considered quite satisfactory, and the local official agriculturists were instructed to give the greatest possible encouragement to cotton growing by native farmers, which they did very successfully.

In the meantime it was decided that Mr. Fisher should visit the Sankuru and Kasaï Districts, which seemed very suitable for cotton. The cotton expert left Nyangwe on October 1916, and travelled across country to Ombwe and Lubefu, reaching Lusambo, the head town of the Sankuru District, on October 22. Most of the soils observed on this trip are sandy, with occasional more fertile tracts, some of them of quite appreciable extent.

From an agricultural standpoint, this region is by no means to be despised, according to Mr. Fisher; but the almost entire lack of transport facilities prevents the natives from utilising even the wild products, and much less could they be induced to cultivate field crops for export, such as cotton, tobacco, and ground nuts.

Mr. Fisher had been instructed to select a suitable site for a Cotton Farm in the neighbourhood of Lusambo. He reported as follows on his inspection trip:

"The district around Lusambo is rather hilly, and most of it is heavily timbered. It was somewhat difficult to find a place of sufficient size for our purposes.

"Native farms and new clearings were plentiful, but any land of value was occupied by native farmers, who seem to cultivate the land rather well and intensively. It is remarkable to see the amount of work that is being done by them in clearing forest land with the inadequate tools they possess. They are not afraid to attack virgin forests, cutting down everything. Some of these clearings are of quite respectable size. The whole forest country on every side is dotted with little clearings and little hamlets of from three to twelve or fifteen houses. These small cultivators will in the future produce the bulk of the cotton.

"The soil in nearly all places visited consisted of light sandy loam, somewhat too sandy in places, but on the whole of average fertility and in many places rich.

"Unoccupied areas of land of sufficient extent were found, but there was generally some drawback. On some the soil was worn out and worthless; others were overrun with Nyanga or Nyassi grass (*Imperata cylindrica*) and Bermuda grass (*Cynodon dactylon*). A considerable quantity of the latter was encountered on the left side of the river. It was introduced, I understand, by the missionaries; it is very good in its proper place, such as roads, lawns, pastures for cattle, steep slopes, etc., but a nuisance in the field."

Mr. Fisher finally decided on a site at Babadi, near Lonkala, consisting of an abandoned village from which the natives have moved on account of tribal troubles. Babadi is six miles from Lonkala, on the Sankuru River, where the largest river boats (500 tons) can generally be moored to the bank, except at unusually low water.

The climate of Lonkala is very similar to that of Nyangwe, but the nights are cooler on account of the higher altitude.

The rainfall of 1916–17 was exceptionally heavy; while the average appears to be 54 inches (1,350 millimetres), the amount of rain collected between July 1, 1916, and July 1, 1917, was 72 inches. Very heavy rains fell in April and May, during the flowering of the cotton plants, and did considerable damage to the flowers and young bolls.

Cotton seed had been distributed to the natives on both banks of the Sankuru River, and hundreds of small fields were sown. Many of them could not be inspected, as there was so much work on the farm at Babadi. However, several native boys, trained in cotton growing at Nyangwe, were sent to the villages and instructed to advise the natives in the cultivation of their plots. This makeshift has given but indifferent results, as some of these native instructors lacked confidence, others were lazy and some overbearing. Out of a dozen instructors only one or two did really good work.

However, in 1918–19 several European agriculturists were sent to the Sankuru and Kasaï cotton fields, and after a period of training under Mr. Fisher they were put in charge of cotton growing in the country stretching from Kabinda (Katanga) to Bena Dibele (Sankuru), north of Lusambo, and to Luluabourg and Luebo in the Kasaï District.

In this manner two cotton-growing districts have been established in Central Congo: their rainfall is given on page 393.

1. The *Maniema district* around Kassongo, Nyangwe and the Kindu-Kongolo railway line (Northern Katanga). This district will be able to ship cotton through Stanley-

ville and the West Coast, or through Tanganyika-Udjidji-Dar-es-salam and the East Coast.

2. The *Kasaï-Sankuru-Katanga district*, with the country surrounding the town of Lusambo and the large native town and Government station of Kabinda (Eastern Katanga). Cotton will have to be shipped by way of the Sankuru-Kasaï steamers, to Stanleypool and Matadi. This second district has extensive savannah lands, and is thickly populated; cattle rearing is generally possible and roads can be easily constructed.

Cotton Growing in Equatorial Congo

The extensive country north of Nyangwe and Lusambo lies in the Equatorial belt, and its rainfall is both heavier and more regular than farther south.

The land is eminently suited for cotton growing as far as the soil is concerned, but the weather is a hindrance to successful cultivation on account of too much or rather too many rains.

Only a short dry season of from four to six weeks can be counted on in January and February, and even this is rather uncertain as to duration and the time of its arrival. This would be quite insufficient to enable most of the varieties of cotton to ripen all their fruit in time for it to be gathered during the dry season.

Some short-stapled varieties with a short-growing and very quick-ripening season might be experimented with to some advantage, and for that reason several hundred kilos. of seed of the Simpkins' variety have been sent from Nyangwe to La Tshopo. As this cotton matures in from three to three and a half months, and ripens nearly all its fruit in the two months following, there might be a chance of success in the growing of this variety.

Also some seed of the Triumph variety was sent to La Tshopo, but it is very doubtful if this cotton will succeed, as it takes fully four months, after the first bolls open, to ripen all its fruit. Moreover it has other disadvantages, which make it unsuitable for cultivation in a district with many rains and without a well-defined and lengthy dry season. It has a long growing season before it arrives at

Rainfall in Central and Northern Congo Districts

	Nyangwe (Maniema)				Lonkala (Sankuru)			Lusambo (Sankuru)			Api (Lower Uelle).[1]			
—	1916	1917	1918	1919	1917	1918	1919	1916	1917	1918	1916	1917	1918.	1919.
January	206.3	195.9	120.9	79.7	100.0	54.5	302.8	187.5	181.1	128.4	45.9	61.3	39.8	176.7
February	106.6	169.4	243.3	173.4	183.3	70.3	274.2	115.0	85.5	49.0	56.6	37.7	27.2	33.7
March	75.1	177.6	52.8	134.0	186.3	134.9	129.0	242.5	61.5	118.5	164.5	105.6	153.8	113.8
April	118.2	292.4	65.5	175.0	229.8	153.3	243.3	147.5	308.0	182.8	110.6	186.9	241.7	122.0
May	98.3	87.6	89.8	104.9	210.1	78.6	71.5	69.5	104.0	92.7	128.8	332.1	300.9	147.4
June	2.9	—	5.0	15.7	—	3.1	4.9	—	—	—	218.6	128.8	257.4	97.0
July	4.5	—	3.2	19.5	52.7	40.6	11.2	37.7	—	31.0	179.3	106.7	207.2	176.2
August	69.9	52.4	48.6	95.7	25.5	123.5	107.2	40.6	96.5	107.4	184.5	143.1	203.8	96.8
September	109.7	74.4	24.0	55.3	117.3	215.5	132.7	171.0	253.0	114.6	151.1	188.1	79.7	291.1
October	77.2	130.9	85.0	61.0	106.9	143.6	106.5	149.0	195.5	129.8	176.8	318.8	139.7	220.3
November	118.7	230.0	177.5	292.8	392.2	177.0	249.2	134.5	238.0	274.4	184.8	30.9	170.8	263.1
December	235.2	95.8	119.0	278.7	234.4	279.9	150.6	256.9	140.0	256.4	64.8	43.8	62.6	63.5
Total mm	1,222.7	1,512.4	1,034.0	1,485.7	1,838.5	1,481.7	1,873.1	1,551.7	1,663.1	1,485.0	1,066.3	1,683.8	1,884.6	1,801.6
„ inches	48.9	60.5	41.3	59.4	73.5	59.2	74.9	62.0	66.5	59.4	42.6	67.3	75.3	72.0

[1] *Api, on the northern side of the Uelle River, is the Government station where African elephants are trained to work.*

maturity, but this is of little importance as the date of sowing could be so regulated that the cotton would arrive at maturity at the beginning of the dry season.

Cotton Growing in Uelle (Northern Congo)

The most interesting district for cotton growing in the northern part of the Congo is the Uelle, the climate of which is tropical and similar to that of Maniema and Sankuru. The country north of the Uelle River is thickly populated and the natives belong to highly agricultural and intelligent races, such as the Azande, Abarambos and Mangbettus.

The rainy season starts here in April and lasts till November; the dry season extends from November to the end of April, with a short period of rain in February.

Trials in cotton cultivation were started in the Uelle and Ituri districts in 1919 by the Vice-Governor, Colonel de Meulemeester, on both sides of the new road leading from Lake Albert to Niangara, Bambili and Aba. Large fields were planted by the natives of the Kilo-Mahagi region, where about 600 hectares (1,500 acres) were planted with cotton and a few other crops. Samples of this cotton have now been received in Belgium and are of good quality.

The Uelle Cotton District will grow in importance as soon as the projected Uelle Railroad connecting the northern reach of the Congo River with Uelle and French Congo is constructed. The cotton has now to be carried down the motor-car road to Buta, and thence by steamer to the Congo River. The total area planted in Uelle in 1920 will be about 5,000 acres, according to the latest information received. The transport of the crop (about 400 tons of lint) will be a difficult problem so long as the railway has not reached Buta.

Cultivation of Cotton in 1917–20

The results obtained during the last four years can be briefly stated as follows:

During the war, the cotton was commandeered by the

Belgian Government and bought from the natives at 20 to 30 centimes per kilogram (nearly 1*d.* to 1½*d.* per lb.).

The native cotton growers of Maniema, Sankuru and Kasaï planted thousands of small plots, averaging from 5 to 7 ares (⅛ to ⅙ of an acre); the hoeing, weeding and picking are usually done by the women and children.

The monetary return of this crop being comparatively high, the number and total extent of the cotton fields are increasing in a satisfactory way. However, the severe attack of influenza in 1918 was a great drawback, as many natives died or were unable to cultivate and gather their crops.

The area of land planted with cotton by the natives was 112·5 acres in 1916; 2,000 acres in 1917; about 2,500 acres in 1918; and 2,000 acres in 1919, the reduction in the last-named year being due to the epidemic of influenza.

The cotton grown was all American Upland of medium staple. The best results were given by "Triumph Big Boll" and the "Simpkins'."

The quality is quite satisfactory, as is shown by the prices quoted for this Congo cotton at Liverpool during the war:

	Congo cotton. *Per lb.*	Middling American. *Per lb.*
March 1917	11–13*d.*	11½*d.*
August 1917	18–20*d*	19½*d.*
September 1917	16–18*d.*	20*d*
December 1917	22–24*d.*	26*d.*
April 1918	25–27*d*	25*d.*
June 1918	25–26*d.*	25½*d.*
September 1918	25–26*d*	26½*d.*
November 1918	22–23*d.*	22½*d.*
January 1919	16–17*d.*	17*d.*

This cotton was sold for the Belgian Government during the war by the British Cotton Growing Association. Since the Armistice, the Congo cotton has been sold in Antwerp.

Owing to the congestion of the Lower Congo Railway, and to the delay in the erection of the two steam cotton ginneries bought by the Belgian Government, the Congo

cotton is despatched in very small lots, of about 10 to 30 tons. The prices in Antwerp were as follows:

	Quantity. Kilos.	Price. Frcs. per Kilo
1919. March 3	642	4·50
	2,157	4·40
April 28	10,670	4·80
	6,905	4·90
	569	4·70
June 9	5,600	5·90
	31,377	6·90
	754	6·25
August 29	915	6·90
October 25	3,452	8·25
	2,284	8·40
November 28	21,212	8·75
1920. January 16	20,519	10·00
January 29	3,569	10·50
February 19	731	11·00
April 5	10,405	12·00

The freight per ton of lint is as follows:

		Francs.
Nyangwe—Matadi	1914	163·25
" "	1917	155·15
" "	1920	337·64
Lusambo—Matadi	1914	86·50
" "	1917	116·00
" "	1920	271·00
Matadi—Antwerp	1914	75·00
" Hull	1917	290·00
" Antwerp	1920	128·00 (per 40 cub. ft.)

Average Yield of Cotton in the Belgian Congo

The average yield of seed-cotton per hectare is 600 to 700 kilos. (528 to 616 lb. per acre).

In fertile fields, however, the yield rises to 1,000 and even 1,500 kilos. (880 to 1,320 lb. per acre) without any application of manure. Periodical dressings of fertilisers, such as cotton seed or some oil-cake, would probably double the average crop.

The average yield of lint is somewhat above 200 kilos. per hectare (176 lb. per acre). To obtain one ton of lint, therefore, requires the produce of 5 hectares or 12½ acres.

The average yield of lint in the United States being 200 lb. per acre and the American crop being usually grown on manured land, the yield of 176 lb. for the Belgian Congo must be regarded as being satisfactory.

European Staff in Charge of Cotton Growing

The cotton-growing experiments and the extension of native cotton growing are in charge of the Agricultural Department, but the District Agriculturists work under the District Commissioner and Territorial Officers. A large increase of staff has been provided for 1920–21; about fifteen Europeans will supervise the work, encourage the natives in the planting of cotton and superintend the cotton markets. The expense borne by the Government will be about 250,000 frs. for 1920–21.

Steam Cotton Ginneries

We experienced great difficulty in 1916–17 in buying hand cotton gins in England, and still more in 1917–18. As the quantity of seed-cotton grown in the Congo was increasing rapidly, the Colonial Minister bought two fully equipped cotton ginneries in Birmingham, Alabama (U.S.A.).

Each has four 80-saw gins and a steam press, with a 80 h.p. engine, and is theoretically able to turn out 10 tons of lint per day (10 hours a day). But in Central Africa this output will probably be reduced to 5 or 6 tons a day, repairs and upkeep being slow and inadequate.

Each ginnery with freight and erecting expenses will cost 300,000 frs. The price includes dwelling-houses and warehouses for seed-cotton and lint.

These ginneries have now been sold by the Government to the new Congo Cotton Company which has been formed recently in Brussels with a capital of 6,000,000 francs, and in which most of the Belgian Cotton Mills hold shares.

Suitability of the Belgian Congo for the Cultivation of Cotton

(a) *Transport*

The Belgian Congo has thousands of miles of waterways navigable by steamers; enormous hardwood forests, and a considerable wealth of gold, tin, copper and diamonds. These assets are specially valuable on account of the fact that the Colony covers the very heart of Central Africa,

and must form the cross-roads where the principal trans-African highways, the steamer and railway lines, already meet or will meet in the future.

The Colonial Minister, M. Renkin, with unshaken faith in the final victory of the Allies, ordered in 1914 that all the work initiated in the Congo should continue, notwithstanding the war. Even railway building was continued, and the Congo River and Lake Tanganyika are now linked up with the South African Railways. New schemes are afoot under the present Minister, M. Frank, for the building of railways and motor roads.

The Colony is now equipped with telephone, telegraph and sixteen wireless stations, comfortable railways and steamers, and more than a thousand trading houses and stations.

The climate is one of the mildest in the equatorial world, as the whole colony is situated on a high tableland, sloping towards the west ; its lowest parts (excepting the narrow belt at the mouth of the river) are more than 1,000 ft. above sea-level.

The Belgian Congo can be reached by a number of rail and steamer lines, affording great facilities for the transport of goods. In fact, few other Central African Colonies are to be compared with the Congo in respect of the work that has been done, and is contemplated, to improve the means of communication.

The routes leading from or to the Congo are the following :

(*a*) From the west : the Matadi and Congo River route, reaching Stanleyville and Lusambo (Kasaï-Sankuru).

(*b*) From the south : the Capetown-Rhodesia-Katanga railway.

(*c*) From the east : the Durban and Beira lines, to Rhodesia and Katanga ; the German East African line ; the British East Africa and Uganda line connecting with the Masindi - Lake Albert route and with the Kampala-Toro motor road.

(*d*) From the north : the Egypt and Sudan route from Cairo or Port Sudan.

In addition to these existing lines, several new connec-

tions are being built or projected: north, the Congo-Nile junction, and its branch running to French Sudan; west, the Lobito line and the Loanda rail and motor route; south, the Beira connections towards Broken Hill and Nyasaland; and east, the Congo River-Lake Albert railway.

A new line was surveyed by the Belgian Government just before the war, connecting Bukama and the Katanga with the Lower Congo Railway running between Matadi and Stanleypool. This narrow-gauge railway is being widened to 1-metre gauge and is being provided with powerful engines that will treble its transport capacity.

Finally a new railway line connecting Stanleypool with the Atlantic coast is projected by the French Colonial Government, and will greatly facilitate the export of produce from the Belgian Congo.

(b) *Native Agriculture*

Thirty years ago most, if not all, of the tribes were inveterate cannibals. When Stanley travelled through the Congo, he had to fight his way down the river.

The Arab slave and ivory traders from Zanzibar and the East enslaved or killed, between 1860 and 1891, hundreds of thousands of Congo natives. The Dervishes of the Egyptian Sudan used to buy slaves and ivory in the Northern Congo districts. The Belgians had to repel the attacks of warlike natives and to fight the slave-traders. The war lasted ten years, and many Belgian officers were killed in battle, murdered by mutinous native troops or died from fever. The Congo acquired a bad reputation for unhealthiness and danger.

Since the country has been thoroughly pacified, the natives are well cared for and their rights protected against any encroachment; conditions of residence compare favourably with those of any other equatorial country in Africa. The evil name of the Congo is now proved to be undeserved, and travellers can reside and trade in that Colony without more personal danger or hardship than in any other equatorial country.

The natives have entirely ceased and forgotten their intertribal and bloody wars and their former cannibalism.

A start was made in 1916 to develop native agriculture, and, as head of the Agricultural Department, I went to Egypt, the Sudan, British East Africa, Uganda, Mozambique and Rhodesia, to gather information about the methods employed in these countries for the improvement of native husbandry.

The study and organisation of native agriculture is now carried out on the following lines:

The District Commissioner of each of the twenty-two districts of Belgian Congo is assisted in agricultural matters by one, or in specially important regions, such as cotton-growing districts, by several, agricultural officers. These begin their work by studying the agricultural methods of each of the various and often numerous native tribes inhabiting the district. Monographs of these studies are published, usually with a number of photographs, in the *Bulletin Agricole du Congo Belge*, a quarterly magazine published by the Belgian Colonial Office.

The numerous varieties of each plant cultivated by the tribes are noted and tested. Seeds and plants, cattle and improved implements are distributed free, and advice is given.

The District Agriculturist must be a good linguist, and possess the confidence of the natives. He reports to Headquarters on the state of native and European agriculture in his district, studies the marketing and transport of crops and suggests any improvement in legislation, administration, transport, roads, cultivation, etc., that he believes profitable to the natives or to the white settlers in his district. He will also be in charge of the agricultural schools for natives that will be organised in several districts.

The introduction and extension of cotton and rice growing were started in 1917, and a law was passed whereby the native can be compelled to make plantations or cultivate export crops for his own use and benefit, provided that the work on these crops does not exceed five days per month. This measure was taken because the natural laziness of the average African was thought to be hopeless.

PLATE VIII

Native Cotton Plantation in the Kasai, Belgian Congo

Fig. 1.—Co-operative agriculture in a native village. The women clearing the ground for cotton.

Fig. 2.—The women hoeing the field.

However, this law has not been called into operation hitherto, as the natives, who are really good agriculturists and traders, soon realised the benefit to be derived from the new crops. The Government guaranteed the sale of the crops at a price remunerative to the native.

As a result of this agricultural propaganda, the natives of the Congo have planted since 1916, in addition to their usual food crops, several million oil-palms, and produced 20,000 tons of rice, instead of as formerly 5,000 tons, and have also grown some very fair cotton.

The Agricultural Department is now collecting information in order to organise systematically a large production of cotton by the natives. This requires, first of all, a suitable and powerful equipment of mechanical transport by river, rail and roads. It is quite easy to get the natives to grow cotton, rice and other crops for export, but the delivery of these crops would exact a very heavy toll of labour from the native farmers, as each of them would have to carry the whole crop on his head or back, in 56-pound loads, to the nearest steamer landing, two or three days' walk from his village. This would mean continuous and tiring work during one to three months of the year. Improvement of mechanical transport on land and water will solve this difficulty.

Careful attention is being given by the District Commissioners and by the Governors of the four Provinces to the use and ownership of land, in order to improve the conditions of native agriculture and to prevent any encroachment on native rights. These rights are, moreover, under the special care of the Judges throughout the Colony.

Cotton as a Native-grown Crop in the Congo

Although direct cultivation of cotton by white settlers is not excluded or hindered by law in any way, it seems that the industry will be carried on principally by the natives, who can produce seed cotton much more cheaply than a settler (Plate VII, fig. 2; Plate VIII).

In fact, the agriculutral work (hoeing, cultivating, weeding, harvesting) in Central Africa is nearly exclusively

done by the women. The men as a rule never work in the fields except to cut away the trees and clear new land. With the exception of this heavy work, they leave the growing of crops to the care of the women, and confine themselves to hunting, fishing and palavering. There are very few tribes in the Congo where the men work in the fields.

This is an important fact, as the development of native agriculture must be such that no excess of work falls on the women, who are already in charge of housekeeping and domestic industries (milling, baking, pottery-making, etc.).

Cotton appears to be a very commendable crop in that respect, as it yields a good sum of money, although entailing no specially hard work : the women and children can easily gather the cotton crop from their diminutive fields.

As the natives never keep account of the length of time devoted to any particular work in their villages, and only consider the final return, they are able to grow cotton at a very low price.

The same natives will ask a comparatively high wage if asked to work for a white settler ; they will do their work rather lazily, and will soon tire. Notwithstanding all agreements, they will walk back to their villages and have another long spell of lazy life. The result is that native labour, however cheap it appears to be, is generally of an expensive kind and very irregular.

Several mechanical and other means could be adopted in order to make better use of native labour, or to work the farm with a very small complement of native labourers. But it is doubtful if these improvements could reduce the cost of direct cotton cultivation by a settler to the low cost of native production.

GENERAL ARTICLES

THE UTILISATION OF BAMBOO FOR PAPER-MAKING

The high price of wood-pulp has caused paper-makers to search for new materials which can be used as a source of paper pulp. The most promising of these is bamboo, and in view of the general interest that is now being taken in this material, the present article has been prepared, which deals more particularly with the occurrence of bamboos in various countries, and technical details regarding the treatment of the stems for pulp manufacture. As costs of production will vary greatly in different countries, no attempt has been made to deal with this side of the subject. Particulars with regard to India, however, are given in the papers and reports by Sindall, Raitt and Pearson, to which reference is made later in this article.

I. General Characters and Distribution of Bamboos

The arborescent grasses known as bamboos all belong to one tribe of the family *Gramineæ*, but are referred to 30 genera and comprise about 550 different species. A few of these extend into the warmer temperate regions, but the great majority are natives of the humid regions of equatorial and sub-tropical latitudes. They grow, sometimes gregariously, in light rich soil, with phenomenal rapidity, reaching many feet in height in a single season. Most of them are perennial, and have more or less branching rhizomes from which rise the erect culms with hollow inter-nodes of varying length, separated by solid nodes or "knots," and secreting considerable proportions of silica in their cell-walls. They yield a pecto-ligno-cellulose, intermediate in character between the cellulose of esparto and that of coniferous wood; and, when crushed and boiled so as to be freed from the starch and other water-soluble matters present, can—at least in the case of most of the species that have as yet been tested—be converted into an excellent, easily bleachable pulp (see p. 422).

The group is mainly Asiatic, 320 of the species belonging to the monsoon region of Asia, and 15 out of the 30 genera and some 136 species occurring in India. There are 179 species, belonging to 8 genera, but mostly to *Chusquea* and *Arundinaria*, which have been recorded from South America; 49 species occur in Japan; about 30 in the Philippines; 8 in New Guinea; 3 in Queensland; 4 in New Caledonia; 2 in the Pacific islands; about 24 in Africa; 5 more in Madagascar; and none in Europe, though a considerable number have been planted for ornamental purposes and have proved more or less hardy in the United Kingdom. Some members of the group reach altitudes of 11,000 ft. in the Himalayas, and some Chusqueas in the Andes extend to the snow-line at 16,000 feet.

A few bamboos—popularly known as "male"—have solid, or nearly solid, internodes, and are, therefore, valued for spear-shafts, etc.; many species, including some of the South American Chusqueas, are slender climbers, and might probably be troublesome as paper materials; and only a few of the dominant East Indian and Philippine species have as yet been tested for paper-making.

Bamboos mostly flower at long intervals—thirty or forty years—all the representatives of any one species in a district coming into blossom simultaneously. After flowering, the "culms," or erect shoots, die, and sometimes the rhizome or "clump" dies also. The dead culms can, however, be utilised for pulp for at least two or three years after they have flowered. Even if the clumps are killed by flowering, new ones will be produced from self-sown seed in five or six years, and culms suitable for extraction will again be available in eight or ten years from the date of flowering. This feature in the life-history of the plants obviously renders it preferable to have more than one species in the district exploited, and makes the last date of flowering an essential consideration in starting a pulp enterprise.

Bamboos grow at very various altitudes, a moist atmosphere being apparently more vitally necessary to them than a high temperature. A. F. W. Schimper (*Plant*

Geography, Oxford, 1903, pp. 233 and 382) sums up the ecology of the group by saying: "Bamboos owe their appearance in vast numbers over the greater part of the tropical zone—Africa is poor in them—chiefly to cultivation. They are, however, also frequently found wild. The largest forms grow in forests scattered among other trees, or they constitute independent forests; smaller forms are common as underwood." "In all probability, the occurrence of natural bamboo woods is also connected with peculiarities of the soil that are less favourable to other trees, since they usually appear only locally, except in the Burmese mountains, where they sometimes cover extensive tracts. Kurz assigns, as the substratum for bamboo forests, rocky or shallow alluvial soil in the case of certain species, and deep alluvial soil in the case of others. Bamboo woods merit the term 'pure' better than any others, for they consist only of one or two species of bamboo, and are devoid of any other plants." Kurz speaks of nothing else but a few mosses and lichens occurring on the ground beneath them; and Sir G. Watt (*The Commercial Products of India*, London, 1908, p. 106) says: "As a rule the bamboo is gregarious, establishing itself so thoroughly over certain portions of wild forest tracts that it very nearly exterminates all other forms of vegetation." The growth of tall species in Burma is so dense as to be very detrimental to the development of the more valuable teak; but—in spite of the above-quoted opinion of Schimper as to their dependence upon soil-conditions—their relation to such other tree-growth appears to be one largely of relative shade-endurance and light-demand, much as that of the birch in the coniferous forests of north temperate regions.

Their light-demanding character largely accounts for the small size of those species that occur as undergrowth of high forest. The exploitation for paper-making of these and of the herbaceous and some of the climbing forms would be difficult. Several herbaceous forms belonging to the genera *Atractocarpa*, *Guaduella*, *Microbambos* and *Microcalamus* have been recently described from Africa, chiefly from the Cameroons. The species of *Pseudostachyum*, *Schizostachyum*, *Nastus*, *Dinochloa* and

Chusquea are mostly slender-stemmed climbing forms, and with the exception of the "Lelebas" (*Schizostachyum*) of Sumatra and the Moluccas occur mostly at high altitudes. The comparatively small patches of bamboo which commonly occur in the midst of mixed equatorial forests would seem to have very often originated in clearings of previous arboreal vegetation, such as result from hurricanes, artificial fellings or forest fires. They are at least useful as indicating the possibility of bamboo-cultivation in such situations.

Bamboos form pure forests of one or two species on mountains in equatorial regions between the zone of timber-trees and that of alpine plants or perpetual snow, whilst below these belts they occur intermingled with the timber-trees. Thus on Mount Kenya, in East Africa, the timber practically ceases at about 8,500 feet, from which height a dense unbroken zone of bamboo (*Arundinaria alpina*) stretches almost to the snow-line. On account of its steep slope, this belt looks from a distance wider than it really is; but, from about 7,700 feet, where it is intermixed with timber-trees, it extends to about 9,000 feet. In South Africa the slender *Arundinaria tessellata* grows from 3 to 25 ft. high at altitudes of 4,000 to 7,000 ft. on the Witte Bergen, Table Mountain, the Bamboesbergen and the Drakensberg: this bamboo is used by the natives for spears and fencing, and (when there was no question of its use for paper-pulp) was said (*Kew Bulletin*, 1909, p. 59) to be "obtainable in any quantity." Another slender Arundinaria (*A. nutakayamensis*) grows in sphagnum-bog at 7,000 to 9,000 ft. altitude in the Philippines; and other species reach altitudes of 5,000 ft. in the Organ Mountains of Brazil, 8,000 ft. in Ceylon and 11,000 ft. in the Himalayas. In Java, *Gigantochloa aspera*, in conjunction with *G. maxima* and *G. ater*, species also represented in Sumatra, Singapore and the Moluccas, forms extensive forests at altitudes between 2,000 and 4,000 ft. In Borneo, Miss Gibbs describes *Bambusa Gibbsiae* on Mount Kinabalu as forming scrambling undergrowth at altitudes below 9,000 ft., and species of *Gigantochloa*, *Schizostachyum* and *Dinochloa* as occurring sporadically in local groves. In

New Guinea, Miss Gibbs describes *Gigantochloa novo-guineensis* as occurring in the same way at similarly moderate altitudes, though Sir D. E. Hutchins stated that there is a zone of bamboo above the forest and below the Alpine region, just as on the mountains of East Africa. In the Amazon forest-region the stouter bamboos (*Guadua* more especially) occur sporadically on relatively low-lying alluvial tracts, while densely tangled slender Chusqueas and shrubby Arundinarias are found in moss-forests on high, and often hardly accessible, situations.

II. Occurrence and Utilisation in various Countries

In this section particulars are given of the distribution of bamboos throughout the world, especially from the point of view of their utilisation for paper-making, and of the present position and prospects of the industry in certain countries.

India.—Excluding timber, bamboos form the most important forest product of India. In 1896 Gamble estimated that the annual Indian consumption of bamboos must be something like 150 millions per annum. From the forests of Burma alone over 80 millions were extracted annually during the five years ending 1918–19, entirely to meet the needs of the natives. The supply, however, is far in excess of the local demand, and in some localities, referred to later, enormous quantities are available for paper-making.

The possibility of utilising Indian bamboos on a commercial scale for the manufacture of paper was first investigated by T. Routledge in 1875 (*Bamboo considered as a Paper-making Material*, London, 1875, and *Bamboo and its Treatment*, London, 1879). In 1905 R. W. Sindall, at the request of the Government of India, investigated the possibility of manufacturing paper-pulp in Burma, and his report on *The Manufacture of Paper and Paper Pulp in Burma* (Rangoon, 1906) contains a detailed account of the value of bamboos for this purpose. Sindall also dealt with the subject in his *Bamboo for Paper-making* (London, 1909). During recent years much work has been done in India by W. Raitt ("Report on the

Investigation of Bamboo as Material for Production of Paper-pulp," *Indian Forest Records*, 1912, **3**, 181), and by R. S. Pearson (" Note on the Utilization of Bamboo for the Manufacture of Paper-pulp," *Indian Forest Records*, 1913, **4**, 159).

The most suitable Indian bamboos for paper-making, from the point of view of abundance and availability, are *Bambusa polymorpha* (" kyathaung "), *Cephalostachyum pergracile* (" tinwa "), *Bambusa arundinacea* (" dougi ") and *Melocanna bambusoides* (" muli "), all of which have been found to give high yields of pulp. Manufacturing trials have been made from time to time on a commercial scale with Indian bamboos, Sindall's *Bamboo for Paper-making* being printed on paper made in England from *Bambusa polymorpha*, whilst Pearson's *Note* referred to above was printed on paper made in India from the same species. Concessions for working the bamboo forests in a number of localities have been granted, or are at present the subject of negotiations, and it is to be expected that in the near future paper will be manufactured from Indian bamboos on a large scale.

The largest areas of bamboo forest in India occur in Burma, Bombay, Madras, Assam, Mysore and the native State of Cochin.

No country in the world would seem to have more extensive natural and accessible areas occupied by the larger and more valuable bamboos than Lower Burma. The area of bamboo forests has been stated to be over 2,400,000 acres, with a possible output of at least 1¾ million tons of dry stems per annum. The forests are under the control of the Government, who offer to reserve areas, and grant factory sites rent free for 21 years, charging no royalty for 7 years, and then only one rupee per ton, provided the factory be built within 2 years, and be worked 120 days per annum with an output reaching 10,000 tons after 7 years, and 20,000 after 14 years.

Pearson describes five areas in Burma suitable for the extraction of bamboos. Two of these, the Thonze Reserve of the Tharrawaddy Division and the Hlaing Yoma and Okkan Reserves of the Rangoon Division both on the west slopes of the Pegu Yoma range, draining into

the Myitmake or Rangoon River, and also on the railway, could be worked together by a mill situated near Insein, above Rangoon. They comprise together 178,000 acres, " tinwa " (*C. pergracile*) and " kyathaung " (*B. polymorpha*) being the prevailing species, and forming about 80 per cent. of the bamboo growth in the Hlaing Yoma and Okkan Reserves, with some " myin " (*Dendrocalamus strictus*) on higher ground. A Calcutta firm, working in conjunction with a large Scottish firm, applied for a lease of this area in 1917–18. The third area described by Pearson comprises over 271,000 acres, covered mainly by the same species, in the neighbourhood of Pyinmana, on the Sittang River and near the Mandalay Railway, east of the Pegu Yoma range. A Rangoon firm is stated to have commenced work on a small scale in Pyinmana in 1917–18. The fourth area, or Toungoo Division, comprises over 74,000 acres, chiefly of " kyathaung," in three districts lower down the same river-valley, and on either side of the river. The Calcutta firm above-mentioned appears to have been also in treaty for this concession. Pearson's fifth area comprises upwards of 3,000 square miles in Arakan, in the valleys of the Seik Chaung, Kaladan and Lemru Rivers above Akyab, mainly occupied by *Melocanna bambusoides*, the " muli " or " kagin " bamboo, which flowered between 1908 and 1912. Certain coastal areas in Arakan and others near Moulmein have been reported on by Raitt, and leases have been applied for by a large London firm and a Bombay Syndicate. Farther north, the Kasalong Reserve on the Chittagong River was inspected by Pearson in February 1919 with the representative of a Calcutta firm, which has now applied for a lease.

In Bombay the chief bamboo areas are on the west coast of Canara, and have an aggregate area of over 172,000 acres of first-class, and 36,000 acres of second-class, forest. Three suitable factory-sites are described by Pearson, viz. (1) at Gumbala on the Gangavalli, 14 miles from the sea, (2) near Kalamani on the Kalinadi and (3) at Hubli, a station on the Madras and Southern Mahratta Railway. The prevalent bamboo is *Bambusa arundinacea*, known locally as " dangi."

In the Madras Presidency suitable areas exist in three groups of detached brocks, situated respectively in South Canara above Mangalore, in North Malabar above Tellicherry, and in South Malabar between the Nilgiris and Calicut, with an aggregate extent of over 64,000 acres, and an estimated annual output of 23,000 tons of pulp. The prevalent species is dangi. It is understood that during 1917–18 a Bombay firm was in treaty for a lease of West Coast areas. An area described by Pearson (*Indian Forester*, 1920, **46**, 555) as "not unattractive" exists in the Surat Dangs, and there is another possible area in the Hoshangabad Division of the Central Provinces, where a pulp-mill for bhabar grass (*Ischæmum angustifolium*) and bamboo is in contemplation.

There are valuable forests in Mysore, and in 1917 a combined pulp and paper factory, with an annual output of 5,000 tons of pulp, was projected for Tadasa in this State. Shimoga, on the railway, has also been approved as a site by Raitt. It was estimated that 28,500 tons of the large and excellent myin bamboo (*Dendrocalamus strictus*) can be obtained annually in this neighbourhood.

There are seemingly valuable forests near Trichur in Cochin, which are near a shallow backwater and also on the railway; these are under organised management, and have an abundant available supply of cheap labour. A factory for 200 tons of pulp weekly has been proposed for this area. The prevalent bamboo in Cochin and Travancore is *Ochlandra travancorica*, known locally as "elephant grass"; and Raitt has obtained such excellent laboratory results from this material that a Bombay Syndicate and a large London firm have applied for leases of the areas on his recommendation.

In Assam, according to a Report of the Deputy Conservator of Forests, "there are, both in the Brahmaputra Valley and in Cachar, thousands of acres covered with bamboos, frequently quite as dense as any plantation could be planted; and in other localities only slightly intermixed with other vegetation." The Report indicates localities suitable for establishing factories. It is probably to exploit part of the Assamese supply that Messrs. Nelson

of Edinburgh have erected a large mill in the neighbourhood of Calcutta, which is being equipped by a British firm.

Ceylon.—Bamboos occur in the southern lowlands, and at a height of 4,000–5,000 ft. in the mountains of the interior. The small, slender bata-li (*Ochlandra stridula*) is described as " covering hundreds of square miles " in the former region, and three species of *Bambusa* (*B. arundinacea*, *B. vulgaris* and *B. nana*) are cultivated and much used in building. All these could probably be utilised as paper material, though no manufacturing project has yet been put forward. In the montane region, slender shrubby species of *Oxytenanthera* (*O. Thwaitesii*) and *Teinostachyum* (*T. attenuatum*) and five species of *Arundinaria* occur.

Indo-China.—It has been estimated that there are from 50 to 90 species of bamboo indigenous to French Indo-China, including several of those shown to be suitable for paper-pulp in Burma. Pulp has been made wholly or partly from bamboo in Tonkin during recent years at two factories, one at Dapcau, near Hanoi, having an output of 150 tons of paper a month, and the other at Viétri with an output of 250 tons. Pulp from the latter reached Bordeaux during the war in 400 lb. bales, hydraulically pressed, hooped, and packed in gunny at £12 10*s.* per ton ; and some of this appeared on the English market.

A. Chevalier has given an account of the manufacture of paper from bamboo in Tonkin in the *Bulletin Agricole de l'Institut Scientifique de Saigon* (1919, **1**, 188), based partly on an article in the *Réveil économique de l'Indochine* for March 16, 1919. The factory at Dapcau at first manufactured only wrapping paper, but towards the end of 1918 caustic soda became available, and since then various qualities of paper have been produced, including newsprint, note-paper, drawing-paper and blotting-paper. Three newspapers are now being printed in Indo-China on paper made at this factory. Bamboos form the greater part of the raw material used in the Tonkin paper-mills, other materials employed being lalang grass (*Imperata arundinacea*), rice husks and old rags. A botanical investigation of the bamboos chiefly used is being conducted, but so far suitable flowering material has not been available

to enable the species to be identified. Three kinds are used at the Viétri factory, known under the native names, "nu'à-dai," "nu'à-bây," and "nu'à-tép." The second, which is of medium thickness, is chiefly used, as the first-named, a thick-stemmed form, is in demand by the natives for other purposes, and the price is consequently high, whilst the last is thin, with a maximum diameter of 2 cm. Chevalier believes that these bamboos belong to the genera *Bambusa* and *Dendrocalamus.* All three occur in large quantities in the neighbourhood of the Red River, in the provinces of Tuyen Quang and Yen-bay, and are brought by sampangs to the factory at Viétri, which is situated on the river-bank.

China.—In Southern China—most of which is extra-tropical—there are apparently extensive areas under bamboos.

At least 60 kinds appear to occur in the country. *Phyllostachys heteroclada,* "chung chu," which is less than 20 feet in height, is abundant in Central and Western China, especially in alluvial areas, but is also found up to altitudes of 4,000 ft., commonly forming extensive groves, and in western Hupeh is commonly employed for paper-making by local methods; while the larger *P. nigra,* "pan chu," 30–40 ft. in height and 3–4 in. in diameter, is one of the commonest species throughout the Yang-tsze Valley. Bamboos are, in fact, the only woody plants that are abundant throughout all but the coldest parts of the Middle Kingdom, their stems being by far the most important "timber" in the country. Bamboos form a large proportion of the woods in Fukien, and provide the material for the paper industry; in Hunan the river-banks and the adjacent country are stated to be covered with bamboo-groves, and much paper is made; in Kwangtung (Canton) the bamboo is said to grow everywhere, but is exported especially from the Bamboo River; and in North Honan groves of cultivated bamboo flourish. When the climate was less dry than it is at present bamboos abounded in a wild state, their northern limit being now Southern Shensi and Kansu. In Szechuan they are ubiquitous, specimens 80 ft. long being made into rafts on the Ya River, and

paper being largely manufactured from them. Sir A. Hosie (*On the Trail of the Opium Poppy*, vol. i, London, 1914), writing of the last-named province, states: " The road frequently passing through dense bamboo forests. . . . Nowhere in China had I seen bamboo forests on such a large scale. Needless to say, numerous small factories were busy converting them into paper; but the bamboo is such a fast-grower that they seemed to be making little impression on these wonderful forests." E. H. Wilson (*A Naturalist in Western China*, vol. ii, London, 1913) identifies these Szechuan species as " tz'u chu " (*Bambusa arundinacea*), producing stems 50 to 75 ft. in height and 8 to 10 in. in diameter, and forming compact clumps which are impenetrable on account of their density, ferocious spines and very thick wood; "nan chu " (*Dendrocalamus giganteus*), the largest species in the country, 60 to 80 ft. in height and 10 to 12 in. in diameter, with thin light wood and forming wide-spreading groves; and the thin-wooded " kwangin chu " (*Bambusa vulgaris*), commonly cultivated but less valuable as timber. These Chinese bamboo-groves seem—in most cases at least—to be the result of deliberate cultivation, the plants having been accepted by the people in lieu of timber-trees.

Japan.—Although numerous species are indigenous to Japan, including no less than 17 species of *Arundinaria*, and it is stated that there are lands suited to bamboo throughout the country, bamboos would seem to be only the objects of sporadic cultivation, the large quantities required for miscellaneous uses being mainly supplied from Formosa, where extensive areas of wild bamboos occur. *Arundinaria kurilensis* is the most northern known species of bamboo.

Philippines.—About 30 species of bamboo occur in the Philippines, where they have been more completely studied, particularly from a botanical point of view, than in any other country (see " Philippine Bamboos," *Bulletin No.* 15, *Bureau of Forestry*, Manila, 1918). They occur at the edge of the forest or in clearings, the climbing species forming impenetrable thickets and being decidedly inimical to the growth of timber-trees. They are in great demand for various purposes, the framework of the

great majority of the houses in the country being constructed of the thick-walled species, while partition walls are built of "sawale," a coarse matting made from the split and woven stems of the dwarf *Schizostachyum lumampao* (*S. mucronatum*) and other thin-walled forms. Considerable experimental plantings of cuttings from several species have been carried out; and G. F. Richmond (*Philippine Journal of Science*, 1910, **5**, A., 237) has found the wild thin-walled *Schizostachyum lumampao* (or caña bojo), treated by the soda process, to be the most satisfactory paper material (see also "Philippine Forest Products as Sources of Paper Pulp," *Bulletin No.* 16, *Bureau of Forestry*, Manila, 1918). This is an erect, gregarious species sometimes reaching 30 ft. in height, and occupying considerable areas with a dense stand, averaging nearly 9,000 canes per hectare. It forms almost pure stands from sea-level to 300 metres, and clumps bearing 15–20 culms are "not infrequently so close together that it is difficult to wedge a way between." In some forests immense tracts of this plant are cut annually and made up into rafts for the market. It is never cultivated.

Malaysia.—The bamboos of Malaysia and the Dutch East Indies, from Java to Borneo, were enumerated by Kurz in 1876. They comprise numerous species of varying size and habit, and form extensive pure forests at various altitudes from sea-level up to 5,000 ft., besides being in some cases cultivated. Among them are several of the species proved suitable for paper-pulp in Burma, such as "tin-wa" (*Cephalostachyum pergracile*) and "tei-wa" (*Bambusa Tulda*). The common bamboo (*Bambusa vulgaris*) or "hower," much cultivated in India, Mauritius, Cape Colony and Tropical America, occurs both wild and cultivated, from the plains to 3,500 ft. in Java, Singapore, Celebes and the Moluccas. The spiny bamboo (*B. spinosa*) is abundant from Java to Borneo; and the dwarf *B. nana*, cultivated all over the area, is half-wild in Java and Singapore, especially at 2,000–3,500 ft. Extensive forests, composed almost entirely of "andong" (*Gigantochloa maxima*), a tall, generally cultivated species, "atter" (*G. ater*), which is also cultivated, and "bitoong" (*G. aspera*), occur, particularly at an altitude of 2,000–4,000 ft.

The largest bamboo (*Dendrocalamus giganteus*), which grows 18 inches in a day and reaches 120 ft., and its valuable but smaller ally, *D. strictus*, are also present, together with many slender or climbing species of *Dinochloa* and *Schizostachyum*, which may prove as valuable as is *S. lumampao* in the Philippines.

Borneo.—In many parts of Borneo, the supply of wild bamboo is very small, though it tends to increase where the jungle has been cleared. A. R. Wallace, writing to Sir W. Hooker in 1856, speaks of bamboos as forming a more marked feature of the landscape than in Brazil; but Foxworthy states that they are apparently not "in sufficiently large quantities for the supply of a paper-mill" (*Bulletin No.* 1, 1916, *Dept. Forestry, Brit. N. Borneo*). Lalang grass and dipterocarp timbers have been suggested as possible local materials for the manufacture of paper-pulp.

Tropical Australia.—Three imperfectly known species of bamboo have been described from the northern parts of the Australian continent. *Bambusa arnhemica*, from Arnhem Land, may be identical with *B. Moreheadiana*, a tall, climbing, thick-walled species from the Russell River scrubs of North Queensland. *Arundinaria Coboni*, a tufted, erect, thin-walled plant, 26 ft. or more in height and 1½ in. in diameter, was found in rich alluvial soil near the head of the Starcke River, in North Queensland, at an altitude of 500 ft. None of these species seems to be abundant.

Pacific Islands.—The chief species indigenous to the islands of the Central Pacific, from Hawaii to Samoa and Fiji, is *Schizostachyum glaucifolium*, a slender shrub some 9 ft. high, often cultivated, but not occurring in a markedly gregarious manner when wild. It has not been tested as a paper material.

Tropical America and the West Indies.—Most of the bamboos of America belong to genera peculiar to the New World, *Guadua* taking the place of *Bambusa*, *Chusquea* that of *Schizostachyum*, etc., only *Arundinaria* and *Nastus*, perhaps, being indigenous to both hemispheres, although some Asiatic species have become naturalised in the West Indies. The reed-bamboos (*Arundinaria macro-*

sperma and *A. tecta*), which are of no great height, form the low-lying extra-tropical "cane-brakes" which characterise the most northern extension of the group on this continent, the first-named occurring in Florida, and on the shores of the Mississippi and in Arkansas, whilst the second is found in Kentucky and near Philadelphia. Forty years ago a considerable quantity of paper-pulp was annually made from *A. macrosperma* in North and South Carolina and the lowlands of the Mississippi. The cane was cut into pieces, tightly packed in cast-iron cylinders, 22 ft. long and 1 ft. in diameter, known as "guns," fitted with very strong steam-domes. After 15 minutes treatment with steam at 180 lb. pressure, the cane was shot out of the gun against an iron sheet by the sudden opening of one end of the cylinder and thoroughly disintegrated by the expansion of the compressed absorbed steam. The utilisation of this species by modern methods is now under consideration in Louisiana.

Most of the taller species of the small related genus *Arthrostylidium* occur at high altitudes. The slender *Arthrostylidium racemiflorum*, for instance, grows at 6,500 to 7,500 ft. in Mexico, and the taller and stouter *A. Schomburgkii*, the long, basal joints of which—the longest of known bamboos—are used for the native blow-tube or "sarbican," occurs at 6,000 feet in Guiana and in the mountains near the sources of the Orinoco and Rio Negro. *Chusquea aristata* occurs in the same region in dense thickets at 13,000–15,000 ft. *Guadua angustifolia*, which grows to 30 or 36 ft. in height and to 6 in. in diameter, is described by Humboldt as "forming forests several leagues in extent in hot valleys and at moderate elevations" (about 2,400 ft.) in Ecuador and Colombia, but the species of this genus probably more often occur in comparatively small thickets.

A considerable portion of the area occupied by gregarious bamboos in Trinidad is made up of introduced Asiatic species, especially *Bambusa vulgaris*, though the nearly allied Venezuelan species, *Guadua latifolia*, also occurs, and at high altitudes the large *Arthrostylidium excelsum* and *A. pubescens* are found. Paper has for some years been made in Trinidad more or less completely from

bamboo-pulp, and Messrs. Nelson of Edinburgh have a concession for cutting bamboo in the Government forests, and have planted 1,000 acres near St. Joseph, 7 miles from Port-of-Spain.

Though bamboos occur generally throughout Jamaica, they do not occupy extensive continuous areas; and although under present conditions they might be remuneratively cultivated, a London newspaper, which some years ago took for a time a considerable quantity for paper-making, abandoned the enterprise because the supply was inadequate. So, too, in British Guiana, though several useful species occur sporadically, and there would be little difficulty in cultivating them, they do not appear at present to occupy any large continuous areas.

Africa.—The cultivation of bamboos, especially of species of *Phyllostachys* from the Himalayas, has been suggested for Morocco and the coast of Algeria to fix sand-dunes and to dry up marsh land, some species being stated to withstand drought or frost. *Oxytenanthera abyssinica*, the most widely distributed African species, the stems of which attain a height of 50 ft. and a diameter of 4 in., ranges from Lake Tsana in Abyssinia to Liberia, Angola and Nyasaland, occurring at altitudes where snow is frequent. In West Africa, with the exception of some small herbaceous species described from the Cameroons, bamboos are only represented by introduced Indian forms, which are grown to a considerable extent on the Gambia.

Reference has already been made to the extensive occurrence of *Arundinaria alpina* in the Kenya forests of East Africa. According to Sir D. E. Hutchins, there are not less than 600,000 acres of bamboo forest on the slopes of Kenya. On the wetter portions of the west side of Kenya, where the bamboo-belt is in places 8 miles across, this species reaches a height of 60 ft. with a basal diameter of 5 in., whilst the lower part of the belt consists largely of valuable yellow-woods, juniper and East African camphor. In the wetter southern half of the Aberdare Range, north of Nairobi, there is about 65 miles of similar bamboo forest with yellow-wood, averaging

3 miles wide and estimated at 124,800 acres; and the same species of *Arundinaria* also occupies the wettest areas of the Mau forest. This East African bamboo has recently been under examination at the Imperial Institute, in order to ascertain its suitability for paper-making. The investigation is not yet completed, but promising results have so far been obtained.

Probably the dense clumps or thickets of considerable extent, with culms of great thickness, which are said to occur all over the Zambesi country of Portuguese East Africa consist also of *Arundinaria alpina* or of *Oxytenanthera*, which are replaced in the extra-tropical highlands of South Africa by *Arundinaria tessellata*. The Germans in 1906 introduced several Indian species into their East African territory.

Bambusa Balcooa, a native of Bengal, has been so completely naturalised at the Cape for about a century as to be known as the "Cape Bamboo"; its stems are used for ladders and whip-handles, and in India for scaffolding. The dwarf Japanese *B. Fortunei* is grown in Natal.

Madagascar.—The province of Galumbulu derives its name from the bamboo known as "bulu" (*Beesha capitata*) which is there dominant; indigenous species of *Nastus*, *Cephalostachyum* and *Schizostachyum* also occur in Madagascar. Several species of *Bambusa* have been successfully introduced in recent years and have been tested at Grenoble, France, and found to yield a satisfactory paper-pulp.

III. Conversion of Bamboo into Paper-pulp

The manufacture of paper-pulp from bamboo consists essentially of the disintegration of the bamboo into its fibrous elements. In order to effect this, it is necessary that some process should be employed which will remove the interstitial gummy or pectinous matter by which the individual fibres are united. Such processes involve the use of chemical agents. The various methods which have been suggested are summarised below.

Comminution

As bamboo offers great resistance to penetration by liquids, it is necessary that it should be submitted to preliminary disintegration or comminution before being digested with chemical solutions. The nodes (or knots) are particularly hard and resistant, and Sindall therefore recommended that they should be cut out and used as fuel.

Raitt has expressed the view that the stems must not be merely chipped, but thoroughly crushed, and that then the whole bamboo (nodes and internodes) can generally be utilised. He states that large bamboos should be split longitudinally and then crushed, so that the whole stem is reduced to a mass of fibrous bundles, somewhat resembling coarse tow. It is claimed that this mechanical treatment gives the following advantages : the nodes can be used and need not be cut out ; two hours are saved in the time required for chemical digestion ; a weaker liquid can be used ; and a more even product is obtained.

In the case of *Bambusa arundinacea* (the species of bamboo occurring in the North Canara District, Bombay Presidency), the stems are exceptionally large, thick-walled and heavy, and the nodes are particularly hard. In a trial made at the Titaghur Paper Mills it was found that this species required more severe treatment than certain others, and it is considered by Pearson that, in addition to crushing the stems, it might be necessary to cut out the nodes.

It is evident that, for the mechanical disintegration of bamboo, it is not sufficient merely to cut the bamboo into small pieces or chips, but thorough crushing is necessary, and possibly in some cases the nodes would have to be removed.

A number of processes have been patented for crushing and cutting bamboo in preparation for chemical treatment, and the essential operations in some of these processes are as follows :

1. The stems are passed through crushing rollers, and are subsequently acted on by drawing rollers to pull

the fibres apart, while the material is held in the nip of the last pair of crushing rollers.

2. The stems are subjected throughout their whole length to a simultaneous rubbing and crushing action. The machine comprises two or more rollers with channelled surfaces rotating at different speeds.

3. The stems are crushed and disintegrated by means of rollers and then cut into convenient lengths for passing to the digester.

4. The stems are first cracked by passing them between rollers, and are then split into two pieces longitudinally by a knife ; the split portions are submitted to crushing and disintegrating rollers, and are finally cut into portions of a convenient length.

Removal of Starchy Carbohydrates

A special difficulty in the preparation of chemical pulp from bamboo arises from the presence of soluble starchy carbohydrates which increase the amount of chemicals required to effect reduction of the bamboo. Moreover, these starchy substances are converted by alkali into dark brown products which render the pulp difficult to bleach, and entail a large consumption of bleaching powder. Raitt has shown that the soluble carbohydrates can be removed by means of boiling water, and therefore recommends that the crushed stems should be boiled with water before being passed to the digester.

Digestion with Chemicals

There are four chemical processes which have been applied to the production of bamboo pulp, viz. : the sulphite, soda, sulphate, and lime processes.

Sulphite Process.—In this process the liquor employed consists of an aqueous solution of bisulphite of calcium or magnesium, and is usually prepared by passing sulphurous acid gas (produced by burning sulphur or pyrites) up towers packed with lumps of limestone or dolomite, through which water is trickling. The digesters usually employed are of steel, lined with lead or acid-resisting

brick. The sulphite process is now the most important of the chemical processes used in the manufacture of wood-pulp.

Raitt has investigated the application of the sulphite process to bamboo, and has found that bamboo pulp, when prepared by this method, has a yellow colour and is much more difficult to bleach than that obtained by either the soda or sulphate method, and that the cost of bleaching would be prohibitive. Moreover, he considers the sulphite process as usually carried out to be unsuitable for use in tropical climates.

The production of the yellow colour is due to the presence of the excess of free sulphurous acid in the liquid in the digester, which is said to char the fibre. J. L. Jardine and T. A. Nelson (Eng. Pat. 18371/1913) claim to have overcome this difficulty. In their process, calcium bisulphite is not used, as a large excess of sulphurous acid is required to keep the calcium salt in solution. The base selected must therefore be one that yields a soluble sulphite, such as magnesium or sodium. The bamboo, previously crushed, is digested with a solution of magnesium or sodium bisulphite which may initially contain an excess of sulphurous acid. During the heating-up of the charge the sulphur dioxide is allowed to escape freely, and during digestion the accumulation of sulphur dioxide is prevented by a free exhaust being kept open during the whole period of digestion. It is claimed that by this treatment a yield of greyish-white pulp is obtained amounting to about 50 per cent. of the original weight of the bamboo. This pulp can be readily bleached to a full white.

In a later patent specification by Jardine and Nelson (1509/1915), a modification of this process is described, and directions are given for preparing a magnesium bisulphite solution containing the requisite proportions of dissolved base and sulphurous acid. By this means the process can be so controlled by adjusting the temperature that the required proportion of base is present without excess of sulphurous acid, and thus scarcely any sulphur dioxide will be volatilised, and during digestion no arrangement need be made for escape of the gas. The specification

describes the application of the method to the stems of *Bambusa arundinacea.*

Soda Process.—In this process the liquor used for the digestion consists of an aqueous solution of caustic soda. The caustic soda is recovered by evaporating the liquor and re-causticising the residue with lime. The process has been studied in relation to bamboo by Sindall and also by Raitt.

Raitt (*Indian Forest Records,* 1912, **3**, 181) has worked out the conditions under which the soda process proves satisfactory, after the bamboo has been crushed and the starch and other soluble carbohydrates extracted by means of boiling water. A satisfactory clean pulp is obtained which can be readily bleached. If the bamboo is digested directly with caustic soda of the usual strength without previous treatment with boiling water, the starch is converted into dark-coloured products which remain in the pulp and render it difficult to bleach.

Raitt has also devised a "fractional digestion" process (Eng. Pat. No. 15779/1912) for treating the bamboo in successive stages. The raw material is first treated with hot water to remove starch and similar soluble carbohydrates. It is then digested with caustic soda of a strength and at a temperature sufficient to effect the breaking down of the pectose, but to leave the lignins unaffected. Subsequently a stronger solution of caustic soda is employed under temperature and pressure sufficient to effect the resolution of the lignins. The final liquor may be used as a preliminary solution in the treatment of fresh material.

According to a modification of this method (Eng. Pat. No. 16488/1915) the preliminary treatment with hot water is omitted, and the bamboo is digested directly with a solution of caustic soda, which is so dilute that the starch is dissolved without the formation of the dark-coloured substances. The bamboo is subsequently treated with caustic soda of greater strength, as in the original process. It is claimed that by this "fractional digestion" process, the cost of manufacture is reduced and bleaching facilitated.

Sulphate Process.—The liquor used in this case consists

initially of a solution of sodium sulphate and caustic soda. After digestion with the bamboo, the liquor is evaporated and the residue incinerated. In the course of these processes, the sulphate becomes reduced to sulphide by the organic matter dissolved from the bamboo. The resulting ash is dissolved in water, rendered caustic by being boiled with lime and used again, the loss of strength being made up by the addition of sodium sulphate.

Raitt found that this process gives a slightly larger yield of pulp than the soda process, that the pulp is of a paler colour and more easily bleached, and that the cost of chemicals is rather less. He therefore regards the sulphate method as the best for bamboo in respect both of cost and quality of the product.

Pearson, referring to Raitt's results, states : " Whether the results obtained by the sulphate process in a mill will be equal to those obtained with caustic soda and whether the resultant half-stuff is of equal quality remains to be proved."

Lime Process.—This process, in which the raw material is digested with milk of lime (lime and water), is applied to straw, especially in Holland, for the manufacture of a half-stuff, suitable for the manufacture of straw-boards and coarse packing paper.

A process of this kind as applied to bamboo is the subject of a patent (No. 14871/1911) of McRae and Malcolmson. In this method the bamboo, having been previously prepared by cutting and crushing, is digested with water containing lime in quantity varying between 5 and 25 per cent. of the dry weight of the raw material, for a period of 4 to 16 hours, depending on the steam pressure, the grade of material and other factors. The pressure employed may vary between ordinary atmospheric pressure and about 100 lb. to the square inch. After the boiling operation the product may be allowed to mellow by being left in contact with the liquor for some days, and is then washed and disintegrated in some form of breaking engine.

This process would be very inexpensive, but the product would consist of a brown pulp, which would not be in a condition for bleaching.

Of these various processes, the ordinary sulphite method is obviously unsuitable, particularly for work in India. Jardine and Nelson's modification might possibly give good results under competent supervision, but it would require a good deal of careful manipulation for the adjustment of temperature, etc.

The soda process has given satisfactory results in the hands of both Sindall and Raitt, and can be readily applied to grasses and other products in case the supply of bamboos should run short.

The sulphate process is largely employed in Europe for the production of pulp from the wood of coniferous trees. The main objection to it is the production of evil-smelling volatile by-products. In view of Raitt's experiments, it seems possible that this process might prove superior to the soda process for bamboo.

The soda and sulphate processes yield pulp which is well digested and could be easily bleached. The lime process, however, results in the production of a brown pulp of a much poorer quality and incapable of being bleached. As bamboo is capable of yielding a high-class pulp, it seems a pity that it should be used for the manufacture of such inferior material. There is, however, a possibility that the comparatively low value of the pulp might be more than compensated by the high yield of pulp and by the low cost of the chemicals used, and that it thus might be more profitable to produce the brown half-stuff by the lime method than to manufacture a good-class soda-pulp.

IV. General Conclusions

The experiments so far made have clearly proved that a high-class paper can be produced from bamboo pulp. On the whole, it is too good for the manufacture of ordinary news-print, and is more suitable for better grades of printing paper. A firm of paper-makers in Ireland, to whom a sample of bleached pulp was sent with a view to experiments being made on the manufacture of a thin sheet suitable for lithographic printing, stated that the paper was put through the mill just as if wood-pulp were being treated, and that no difficulty whatever

was encountered and no alterations were required with the machine. Lithographic printers who tried the paper reported that it takes both letterpress and litho-work admirably; it was put through the litho-machine twice, and from the register marks no stretch was shown (Sindall, *Bamboo for Paper-making*, 1909).

The occurrence of various native or introduced bamboos at various altitudes, in many countries, is sufficient to show that, where they do not already exist in sufficient quantity to be exploitable for paper-pulp, there would be no difficulty in introducing and cultivating those species which have been proved suitable for this purpose. Many species, in addition to the half-dozen already thoroughly tested in Burma and the Philippines, will also probably prove capable of commercial utilisation.

The cultivation of the bamboo for paper-pulp offers a number of advantages over spruce and other pulp-woods. As already mentioned (see p. 404) bamboo culms are available for extraction within 8 or 10 years from the time of sowing, and, if a proper system of rotation cutting is adopted, their cutting can be continued for a period of 30 years or more, that is, until they flower. Propagation of the bamboo is relatively simple. The most effectual method is by seed, but, as this is not always available, the usual method is by cuttings of half-matured culms. These are about 3 ft. long and should include, if possible, part of the rhizome. They may be inserted vertically direct in their final position, with the two lowest nodes buried, or they may be placed horizontally in prepared beds. In the latter case a shoot arises from each node, and the young plants are later separated and set out in the plantations.

The area of bamboo forest required to supply a pulp-mill depends on the yield of pulp obtainable from the stems, and the quantity of bamboos that can be cut per acre. The work of Sindall, Raitt and Richmond has shown that the yield of pulp varies somewhat according to the species of bamboo employed and the method of treatment, but it may be reckoned that the average yield is about 40–45 per cent. In other words, approximately 2¼–2½ tons of air-dried stems, including both

nodes and internodes, would be required to produce one ton of air-dried pulp.

Pearson has calculated in detail the yield of stems obtainable from natural forests in the case of different species in a number of selected areas in Burma, Bombay and Madras. Neglecting certain areas in Bombay, the approximate yield of dry internodes per acre was found to vary from 2·2 tons in the case of *Bambusa arundinacea* in the East Canara Forest Divisions of Bombay to 17·6 tons in the case of *B. polymorpha* and *Cephalostachyum pergracile* in the Pyinmana and Toungoo Divisions of Burma. These estimates were made on the assumption that the nodes would not be used, but if these are included the yields would be increased by 15 per cent. in the case of the first-named species, and 10 per cent. in the other two species mentioned. From the figures quoted in *Bulletin No.* 16, 1918, *Bureau of Forestry, Philippines*, it would appear that 14·25 tons of dried stems per acre are obtainable in the case of *Schizostachyum lumampao* in the Philippines. Pearson considers that the bamboos should be cut on a five years' rotation. On this basis, and using, also, his figures for the yield of stems, it may be calculated that the area required to supply a factory in India producing 300 tons of pulp per week will vary from 9,000 acres in the more densely covered localities to 80,000 acres in the poorer forests. Raitt (*World's Paper Trade Review*, Sept. 27, 1907) suggests a three years' rotation, and considers that 5 tons per acre of air-dried bamboo (without nodes) could be cut annually in India. Sindall (*Bamboo for Paper-making*, 1909) accepts Raitt's estimate as a basis, so that on this assumption a mill making 300 tons of pulp weekly would require at least 7,000 acres of forest uniformly covered with bamboo. Allowing for roads and areas not covered with bamboo, Sindall estimates that 14,000 acres would be required to supply a mill of the capacity mentioned. Pearson's estimates of yield are based on actual measurements on a large number of sample plots, so that the calculations given above, which are based on his figures, are probably more nearly accurate.

With regard to the yield obtainable under cultivation,

there are at present no reliable data. Much will depend on the species grown. Under the best conditions in the Burma forests, the clumps of *Bambusa polymorpha* stand about 20 ft. apart, and *Cephalostachyum pergracile* about 12 ft. apart, giving 112 and 300 clumps respectively to the acre. Trials are necessary to determine the most suitable distance at which the seeds or cuttings should be planted, but, if the species mentioned are set out at the above distances, the annual yield of air-dry stems per acre on a five-year rotation cutting system would be about 4¼ tons in the case of the first and 2½ tons in the second, the yields of air-dry pulp per acre being 1·9 and 1 ton respectively. On this basis an area of about 8,000 acres, exclusive of roads, would be required to be planted with *B. polymorpha* to supply a factory producing 300 tons of pulp per week, whilst if *C. pergracile* were planted an area of about 15,000 acres would be required. It seems highly probable, however, that the clumps could be planted more closely without reducing the yield per clump, so that it may be found in actual practice that smaller areas than those mentioned would suffice.

In selecting a site for a paper or pulp mill using bamboo, there are a number of considerations that have to be taken into account, which are common to all paper or pulp mills. Such are: proximity to supplies of fuel and chemicals or to a port to which they can be shipped, adequate labour supply, and abundance of fresh water at all times. On account of the bulky nature of bamboos, it is essential that the factory should be situated on or close to a river which is not subject to periods of too great flooding or dryness, so that the stems can be transported cheaply from the forest throughout the year. Pearson (*Indian Forester*, 1920, **46**, 554), referring to Indian conditions, states that an annual supply of at least 20,000 tons of air-dry bamboo should be available within reach of the factory, whilst it is necessary that the bamboos, which should have little or no local value for local purposes, should be obtainable at a maximum price of Rs. 15 per ton of air-dried stems, landed at the mill.

NOTES

The Platinum Metals: Imperial Institute Monograph.—A monograph on the Platinum Metals, by A. D. Lumb, A.R.S.M., F.G.S., Assoc.Inst.M.M., has been published by Mr. John Murray in the series of Imperial Institute *Monographs on Mineral Resources.*

The book, of 63 pages, is divided into three chapters. The first is principally devoted to the properties of the platinum metals (platinum, iridium, osmium, iridosmine or osmiridium, ruthenium and rhodium), the composition of native platinum and osmiridium, metallurgical treatment, uses of platinum and its allies, alloy substitutes for platinum, and the world's output. The principal countries producing platinum are Russia (90 per cent.) and Colombia (7 per cent.). The proportion contributed by the British Empire is relatively insignificant, the most important source being the residues derived from the refining of the nickel matte produced at Sudbury, Ontario. The amount of platinum obtained annually in the United Kingdom from the treatment of this matte varies from 3,000 to 5,000 ounces.

The second chapter deals with the platinum occurrences and deposits of the British Empire, of which the following appear to be of some importance: The alluvial deposits (placers) of the Tulameen River, British Columbia; the Sudbury copper-nickel deposits of Ontario, in which platinum occurs both native and as sperrylite; the gold-platinum alluvials ("leads") of New South Wales; the placers of the Orepaki district of Southland, New Zealand; and the osmiridium placer deposits of the Bald Hill district, near Waratah, Tasmania. The production of the last-named, which amounted to 120 oz. in 1910, increased to upwards of 1,600 oz. in 1919.

The third chapter describes the deposits outside the Empire, in particular those of the Urals (Russia), Colombia and Brazil. In the last country platinum occurs in placers with palladium (as palladio-gold), in gold-bearing *jacutingo,* as well as in auriferous lenticular quartz masses in schist. The alluvial platinum discovered, a few years ago, at Ronda, Malaga, Spain, is alluded to, as well as the alluvials of Borneo, Mongolia (China), Sumatra and the United States. The occurrence of platinum with palladium in a gold-bearing vein in Nevada is described.

The monograph contains a map showing the platinum-bearing districts referred to in the text, and a bibliography of literature relating to the platinum metals.

Studies of the West African Oil Palm.—There has recently been presented to the Imperial Institute for exhibition in the Public Galleries a series of fifty water-colour drawings illustrating different stages in the life-history of the oil palm (*Elaeis guineensis*, Jacq.). The drawings are the work of the donor, Mr. R. Swainson-Hall, F.L.S., F.R.M.S., who has devoted some years to the study of tropical botany in Portuguese South-West Africa, where these drawings were made.

The drawings are numbered consecutively. The first seventeen figures illustrate germination processes, and show the various stages of growth from the seed to a fully developed plant with two whorls of leaves. The germination is typical of that of monocotyledons, and the drawings of sections of the seed show the foot or "feeder" by means of which the reserve material in the endosperm is assimilated. The shell of the seed appears to remain attached to the plant for some time after all the reserve material has been exhausted; the length of time before it completely decays is said to vary with the nature of the soil in which the plant happens to be growing. The arrangement of the leaf-cycles is illustrated in drawing No. 17. The seven drawings that follow illustrate the male and female inflorescences and give details of the structure of the flowers of each sex. In some cases flowers of both sexes are present in the same inflorescence; an example, cut from a young palm, is depicted in drawing No. 39. Drawings numbered 25 to 34 illustrate the mature fruits and the stages in the natural decay of the pericarp when exposed to sun, rain and air, a process occupying about eight weeks. After the decay or removal of the pericarp of the fruits the remaining portion constitutes the "palm nuts" of commerce, and the oily endosperm which they contain the "palm kernels." These are illustrated in drawings numbered 35 to 38.

Details of the trunk, root and leaves, and the fully developed tree, are the subjects of drawings numbered 40 to 49. A drawing of a magnified pollen grain concludes the series.

As most of the existing groves of oil palm in West Africa originate from self-sown seed, scanty attention has been paid in the past to the study of the early stages of development in the life-history of this important economic plant. In view of this Mr. Swainson-Hall's drawings form a valuable record, and, in the Public Exhibition Galleries, they serve to supplement the actual specimens of palm fruits, nuts and kernels which are on view in the Nigerian Court.

Fibre of Hibiscus cannabinus, with Special Reference to South Africa.—This product is cultivated in India, chiefly in Madras, and also in Bombay, Bihar and the United Provinces, and is known as "Ambari hemp," or "Deccan hemp." A large quantity of the fibre is produced in Madras and exported to the United Kingdom, where it is marketed under the name of "Bimlipatam jute" and realises prices approximately equal to those of medium grades of Calcutta jute. The fibre is somewhat coarser than true jute, but is employed for the same purposes, viz. for the manufacture of sacking, hessians, cordage, etc. A study of *Hibiscus cannabinus* has been carried out by the Agricultural Department in India, and seed of the best races has been selected for multiplication so that pure seed can be supplied in large quantities to the growers. Certain new varieties of the plant have been obtained by the Department which are of promising character (cf. this BULLETIN, 1911, **9**, 413; 1915, **13**, 652).

The plant is grown in many of the tropical countries of the British Empire, and samples of the fibre from Egypt, Gold Coast and Rhodesia have been examined at the Imperial Institute and reported on in this BULLETIN (1912, **10**, 53; 1915, **13**, 22; 1917, **15**, 10; 1919, **17**, 469).

Hibiscus cannabinus belongs to the natural order Malvaceæ, and is an erect plant with a stem varying in height from 5 to 11 feet (commonly about 8–9 feet) and with a thickness of about ½–¾ inch. The fibre consists of the bast layer of the stem, i.e. the layer between the bark and the woody inner portion. It is prepared by a process of retting similar to that adopted in the case of jute, and described in this BULLETIN (1905, **3**, 254).

The plant is easily cultivated and will grow on almost any kind of soil, but prefers a loamy or rich clay soil containing a fair proportion of sand. The seed should be sown thickly in order to reduce the tendency of the plants to branch. The yield of fibre is stated to be about 2–3 tons per acre.

In the warmer parts of the Transvaal and Natal, *Hibiscus cannabinus* grows wild and is known as the "wild stock rose." It is regarded by the farmers as a pest, particularly in the maize fields, where its presence renders it almost impossible to produce a satisfactory crop. Two samples of the fibre prepared in South Africa were received at the Imperial Institute in 1917.

The first sample, which had been obtained from stems cut green and immersed in water for nine weeks, was of variable character and colour. It was rather harsh, and a considerable portion of the fibre was stiff and gummy, and had

bark adhering to it. The better cleaned portions were dull and weak and evidently over-retted. In general the material was not well prepared. The strength of the fibre was uneven, but fair on the whole. The length ranged from 2 feet 6 inches to 4 feet 6 inches and was mostly about 3 feet.

The second sample, which was stated to have been obtained from stems cut after the seeds had ripened and immersed in water for twenty-seven days, was harsh, and of dirty grey colour, but fairly lustrous. The material was gummy in parts and some adherent bark was present, but it had been more evenly and carefully retted than the preceding sample. The fibre was of fairly good strength, and stronger on the whole than the other sample. It ranged in length from 3 feet to 5 feet, with an average of 4 feet.

The fibres gave the following results on chemical examination, as compared with Indian "Bimlipatam jute":

		No. 1.	No. 2.	"Bimlipatam Jute."
		Per cent.	*Per cent.*	*Per cent.*
	Moisture	8·9	10·4	12·5
Calculated on the dry fibre	Ash	0·7	1·2	1·3
	α-Hydrolysis, loss	13·1	13·5	11·8
	β-Hydrolysis, loss	19·7	16·3	15·1
	Acid purification, loss	3·0	1·0	—
	Cellulose	73·0	72·0	75·4
	Loss on washing in water	2·3	1·2	—

These results show that the present samples were rather inferior to ordinary Bimlipatam jute, in view of the greater losses suffered on hydrolysis and the lower percentage of cellulose. This was doubtless due, however, to the fact that the samples had not been very efficiently prepared, and it is probable that well-prepared South African fibre would be quite equal to the Indian product. A firm of fibre merchants to whom the samples of fibres were submitted considered that they were suitable for use by jute spinners, the first being valued in June 1917 at £45 to £50 per ton, and the second at £45 per ton, assuming that the fibre would be sold in the open market, that is, without official control, which at that time was in force. The pre-war values of the fibre would have been from £15 to £18 per ton.

Both samples were short in staple and not of very good quality, but similar fibre would be readily saleable. The merchants who valued the samples desired to be informed when commercial supplies of the fibre become available.

Considerable attention has recently been devoted to the question of cultivating *Hibiscus cannabinus* in South

Africa, and a small company has been formed for the purpose of establishing and developing the industry. Efforts are being made to encourage farmers to grow plots of hibiscus and prepare the fibre, and the company have undertaken to purchase the crop at satisfactory prices. A hand machine has been devised for brushing the fibre while still wet after retting, in order to remove any adherent bark, and it is understood that the company are prepared to lend one of these machines to any farmer who will undertake to grow the crop. About 200 acres have been planted at Hector Spruit, and reports of the crop are very encouraging. The company contemplate the erection eventually of spinning-mills in Durban with a view to the manufacture of maize-bags, whilst any surplus fibre would be exported. This enterprise, if successful, would prove of great benefit to South Africa, in supplying the jute goods required for packing maize and other produce, and in providing employment for the population.

The Improvement of Egyptian Cotton.—In this BULLETIN (1920, **18**, 117) reference was made to the establishment in Egypt of a Cotton Research Board to combine, co-ordinate and extend research on cotton. In this connection, steps are being taken to strengthen the scientific staff of the Ministry of Agriculture, and special provision has been made for enlarging the Botanical and Plant Breeding Section of the Ministry. Before undertaking an extensive programme of botanical research, the Ministry considered it advisable to have the situation reviewed by an expert botanist, and therefore engaged the services of Mr. H. Martin Leake, Director of Agriculture in the United Provinces, India, who has had great experience in cotton breeding, for the purpose of making "recommendations with a view to the maintenance and improvement of the quality of Egyptian cotton and the increase of its yield." Mr. Leake visited Egypt in May, and again in September–November 1919, and made a study of the cotton crop, both in its early stages and during the picking season. He also discussed the commercial aspects with ginners in Egypt and with spinners in Lancashire. His report, which has now been published (Cairo, Government Press, 1920) will be found of great interest to all concerned in the Egyptian cotton industry.

It is not possible to do justice to this report within the limits of a short notice, but the following notes on some of the conclusions and recommendations may be of interest.

Attention is drawn to the fact that cottons of various

classes are needed to meet the requirements of different sections of the trade, and there must therefore be diversity of production. The development of new varieties is therefore desirable, and these will readily find a market. The monopoly in certain kinds of cotton which has hitherto been possessed by Egypt is gradually declining, as cottons with the characteristics of Egyptian varieties have been produced in certain parts of the United States, and competition may also be anticipated from Mesopotamia and possibly from Sind. It is probable that the supply of Sea Island cotton will diminish in the future, and it is therefore desirable that an effort should be made to establish a cotton in Egypt which will be capable of serving as a substitute for this variety.

From these and other facts regarding the economic conditions affecting the Egyptian cotton trade, the author deduces considerations for the development of a sound policy on the part of the producer, and subsequently recounts the principal lines of investigation which he suggests should be undertaken by the Ministry of Agriculture in order to obtain pure cottons in maximum yield. These different lines of investigation are discussed under the headings of economic, botanical, agricultural, commercial, entomological, mycological, bacteriological and physical. The work which it is considered should be carried out by the Botanical Section is summarised as follows :

"(1) Research : The isolation of races in a condition of purity. (2) Experimental trial : Small cultures grown comparatively under differing environmental conditions. (3) Field Trials : In those tracts only which the trials under (2) have proved suitable. (4) Seed Production : The bulk development of a pure seed supply. (5) Seed Distribution : The organisation of seed supply sufficient to meet the full needs of the tract." For carrying out this work a Botanical Research Farm will be required on which the botanical staff can conduct investigations on the production of pure races. For the trial of the races so evolved experimental plots will be needed in each recognised type tract, whilst for field trials experimental farms will be necessary which should be controlled by the Agricultural Section. Seed farms will also be required for the multiplication of seed, and from these farms the seed will be distributed to the growers.

In order to maintain the purity of the seed, it is suggested that the ginners should be licensed for "taqâwi" (i.e. seed for sowing as distinguished from "tugari," or commercial cotton seed), and that each licensee should keep a record (1) of the cultivators whose crops have provided

the seed, and (2) of the persons to whom seed has been supplied, the kind and the amount of the seed being noted in each case. The circle officer will thus be able to acquaint himself with the source of the seed from which a large proportion of the cotton in his circle is grown and will thereby be enabled to exercise suitable control with a minimum of effort.

A matter of great practical importance is the maintenance of the purity of Sakellaridis cotton, as there is a danger that this cotton may be replaced by an inferior variety, which gives a larger yield and is therefore more popular with the growers. The risk of such an occurrence has been illustrated recently in the case of a variety known as Pelion. Mr. Leake does not consider that such cottons should be repressed, but that a large area should be devoted each year to Sakellaridis and the crop rigorously rogued. If some other form should be produced in excess and Sakellaridis in too small a quantity, it would then be possible to retrieve the situation by increasing the supply of pure Sakellaridis.

In concluding his report, Mr. Leake makes the following recommendations : (1) The maintenance of the purity of Sakellaridis. (2) The establishment of one or more types with the same intrinsic merits as Sakellaridis, but with an improved vegetative habit. (3) The maintenance of the present classes by a system of purification and the establishment of pure races. (4) The development of types agriculturally better suited to the environment, including the demarcation of type tracts. (5) The development of a class of cotton superior in quality to the best Sakellaridis. (6) The division of the country into circles determined, as far as possible, by climatic considerations and each with its experimental farm. (7) The establishment of a seed farm in each of the circles so defined. (8) The introduction of a system of licensing of ginneries for "taqâwi." (9) The introduction of a system of licensing persons desirous of introducing new varieties. Such a system would enable steps to be readily taken to eliminate the cultivation of any new variety, if considered desirable, and to prevent the adulteration of existing varieties.

For the purpose of carrying the above recommendations into effect, the following further recommendations are made : (10) The division of the Ministry of Agriculture into a series of sections, such as botanical, agricultural and commercial sections. (11) The establishment of a Ministerial Cotton Committee, composed of the heads of the various sections concerned with the development of cotton, and possessing power to co-opt. One of the chief functions

of the Committee would be to co-ordinate the work of the various sections. (12) The establishment of an extra-Ministerial Cotton Board for providing co-ordination between the Ministry of Agriculture and certain extra-Ministerial bodies, such as the Domains, the Physical Service, and the Irrigation Board. This Board would thus occupy the same position with respect to the Ministry as the existing Cotton Research Board, but would have somewhat different functions.

Senecio Disease in South Africa.—In the *Lancet* for October 23, 1920, Dr. F. C. Willmot and Mr. G. W. Robertson give an account of a disease of human beings which is attributed to the contamination of wheat by the fruits and other portions of the plants of *Senecio ilicifolius* and *S. Burchellii*. Whole families have suffered from the complaint in the George district of the Cape Province, sometimes with fatal results. The chief symptoms are abdominal pain and vomiting with ascites, whilst in fatal cases dropsy is always present. Post-mortem examination shows cirrhosis of the liver. The symptoms are practically identical with those exhibited in a disease affecting cattle and horses which occurs in South Africa, Nova Scotia and New Zealand.

In South Africa it was suspected that *Senecio latifolius* and *S. Burchellii* were the cause of the disease, known there as Molteno disease, and in 1907 a supply of the former plant was forwarded to the Imperial Institute in order that this point might be investigated. A summary of the results obtained was published in this BULLETIN (1911, **9**, 346). In Nova Scotia, where the disease is called Pictou disease, it is thought that it is due to *S. Jacobaea*, the common ragwort.

A detailed chemical investigation of *S. latifolius* was made in the laboratories of the Imperial Institute by Dr. H. E. Watt, and the results were published in the *Transactions of the Chemical Society* (1909, **95**, 466). Specimens of the whole plant collected before flowering contained 1·20 per cent. of alkaloids, whilst specimens collected after flowering contained only 0·49 per cent. The total alkaloids were separated into their components, which proved to be two new alkaloids, and were named senecifoline and senecifolidine respectively. Both alkaloids crystallise well and yield crystalline salts. Pharmacological trials with senecifoline nitrate and senecifolidine nitrate were undertaken for the Imperial Institute by Dr. A. R. Cushny, F.R.S., of University College, London, who published a summary of his results in the *Proceedings*

of the Royal Society (1911, B, **84**, 188) and in the *Journal of Pharmacology and Experimental Therapeutics* (1911, **2**, 531). Dr. Cushny, as a result of his experiments, concluded that the symptoms and post-mortem findings in animals poisoned by the two alkaloids resemble so closely those induced in cattle and horses by *S. latifolius* in South Africa that there can be no question that the Molteno disease is the result of poisoning by Senecio alkaloids.

Senecio ilicifolius and *S. Burchellii*, which, owing to their presence in wheat crops are believed to have caused the outbreak of Senecio disease recorded by Willmot and Robertson, do not appear to have been examined chemically, but it seems highly probable that they contain alkaloids similar to, if not identical with, those of *S. latifolius*.

As stated by Willmot and Robertson, preventive measures against the disease, both in human beings and in stock, are essential. These will include the extermination of the suspected plants and the more thorough cleaning of the wheat. In Nova Scotia, where a similar disease, caused by *Senecio Jacobaea*, the common ragwort, has sometimes caused serious harm to stock, much attention has been given to the former point, and in 1911 an account of measures which have proved successful in Canada in eradicating ragwort was furnished to the South African authorities. These measures consist, briefly, of adopting a shorter rotation of crops, more thorough cultivation, the use of weed-destroying implements, cutting the plant before the seed is formed, and as sheep do not seem to be liable to the disease, grazing these animals on land infested with the plant.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the BULLETIN *a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India and the Tropics generally. It must be understood that the Imperial Institute accepts no responsibility for the opinions expressed in the papers and reports summarised.*

AGRICULTURE

FOODSTUFFS AND FODDERS

Rice Leaf-hoppers.—Rice leaf-hoppers made their appearance in the Chhattisgarh Division of the Central Provinces in 1914, causing a depreciation in the value of the crop of approximately fourteen million rupees (*Memoirs, Dept. Agric. India, Entomological Series*, 1920, **5**, 207). The insect was first recorded, as a specific pest of rice, in 1910 in Bihar and Orissa, and on its appearance in the Central Provinces prompt measures were taken, with the result that it has not been observed since 1916. The leaf-hoppers, known as "Maho" or "Mahor," are *Nephotettix bipunctatus*, Fabr., and *N. apicalis*, Motsch. They live by sucking the juice of the tender plants and the grain in the ears, and exude a sticky substance known as honey-dew, which, falling on the leaves, leads to the growth of a black fungus. This not only results in a scarcity of grain in the infested district but the straw is rendered insipid and unpalatable to cattle. The article contains a description of the hoppers, an account of their life-history and particulars of the measures adopted for their destruction. As the adult insects are strongly attracted by light, lantern traps are recommended. Another method of control is to go over the fields in July and August, if a break in the rain occurs, with large field-bags 6 feet long, moistened on the inside with kerosene. The bag is attached to a light bamboo frame and worked over the plants at a walking pace against the direction of the wind. The bags are emptied into vessels containing water with kerosene on the surface. Attention is drawn to the necessity of clean cultivation in combating this pest and to the advisability of not allowing grassy lands to remain in the immediate vicinity of rice areas.

Collar Rot of Citrus Trees.—This disease, which occurs in most citrus-growing countries, and is fairly prevalent in Australia, often escapes the notice of growers until serious damage has been caused. Its appearance and treatment

are described in *Agric. Gaz., New South Wales* (1920, **31**, 439). Collar rot manifests itself most frequently by "gumming" on the trunk just above or close to the ground. In many cases the bark in the vicinity is dry and brittle. In young trees the leaves show "yellowing," or chlorosis, especially on terminal twigs, but in older trees chlorosis may not develop until the attack has reached an advanced stage, when the trunk has been nearly ring-barked. Associated with the disease, a fungus parasite (*Fusarium limonis*) is constantly found, which enters the tree at an injured part, goes very slowly through the tissues of the trunk, and if left unchecked accomplishes the ring-barking of the tree. The treatment recommended when "gumming" has been observed is to scrape the earth away from the base of the tree, remove the dried bark apparently infected by the fungus, and paint the wound with a bluestone paste composed of 1½ lb. of copper sulphate, 4 lb. of unslaked lime and 1½ gallons of water. Where collar rot is too far advanced for the tree to be saved by this treatment it should be removed and burned, and the stump-hole limed. Bad drainage is conducive to this disease.

Kudzu (*Pueraria thunbergiana*).—This woody climber, belonging to the bean family (Leguminosæ), has recently attracted attention as a forage crop and is the subject of an article in *Journ. Dept. Agric., Union South Africa* (1920, **1**, 558). An account of the plant is also given in *Circular No.* 89, 1920, *U.S. Dept. Agric.*

Kudzu is a native of Japan, and seldom matures seed in any other country. In Japan the plant has many uses. The thick roots contain large quantities of starch, which is used for human food; the stems contain a fine fibre from which a cloth is manufactured, while the foliage is valued as fodder for all kinds of stock, horses being especially fond of it. The seeds do not germinate well, and to establish a field of kudzu the plants raised in nurseries should be planted out early in spring 10 feet apart each way. It may be propagated by cuttings, but under field conditions many of them fail to grow. The plant grows rapidly, in some cases the stems attaining a length of 60 feet in three months. During the first season the trailing runners cover the ground, in the second season good crops are secured, but usually the largest crops are not obtained till the third and subsequent seasons. Kudzu may be utilised for pasture or for the production of hay, the feeding value of which is said to be about equal to clover and lucerne. In Northern Florida some well-established fields have provided three cuttings of hay per season, and yielded as much as 10 tons

per acre. In South Africa very few experiments have been made with kudzu, and in one series of trials the young plants were killed by frost. In Rhodesia it has proved to be a useful grazing crop, but the stems are considered too tough and fibrous to make good hay.

Oils and Oil Seeds

The Vegetable Oil Industry of the Dutch East Indies.—This industry, which before the war was of but little consequence, has grown immensely during the last few years, and it is anticipated that before long it will develop to such an extent as to be able to utilise all the oil seeds produced in the Dutch East Indies (*The Dutch East Indian Archipelago*, 1920, **3**, 875). Most of the oil-mills are situated in Java, where at present there are fourteen large factories. The greater number of these factories deal only with copra. In addition, numerous small factories exist in the Archipelago, which are owned by natives or Chinese. Most of the large oil-mills are equipped with hydraulic presses, while three are fitted with extraction plant. Owing to the growth of the industry, the factories are continually being enlarged and new ones erected. The output at the end of this year is estimated at about 400,000 tons of crude oil yearly, of which 270,000 tons should be available for export.

Oil is expressed from various oil seeds in the Dutch East Indies, but coconut oil represents 95 per cent. of the total production. The other oil seeds worked are: "katjang" (ground nuts), "djarak" (castor seed), kapok, palm fruits, and, to a smaller extent, sesame, Hevea, tobacco and "tengawang" (Borneo tallow). Palm oil is almost exclusively produced on the east coast of Sumatra, where the large oil-palm estates are situated (cf. this Bulletin, 1920, **18**, 215). In order to produce the 380,000 tons of coconut oil which these islands are estimated to yield during 1920, 600–650 thousand tons of copra are required—an amount which in favourable circumstances the Dutch East Indies are easily able to produce. In general, Dutch East Indian coconut oil (especially the Java oil) has a good reputation on the European and American markets.

The Oil Palms of Central and South America.—An article by H. Jumelle on the oil palms of Central and South America is contained in *Les Matières Grasses* (1920, p. 5507). It deals specially with the botanical identity of the palms, regarding which many incorrect and indefinite statements have been published. Many of these palms have been dealt

with in this BULLETIN, namely, cohune (*Attalea Cohune*), cokerite (*Maximiliana regia*), tucum (*Astrocaryum vulgare*), babassu (*Attalea* sp.), and noli (*Elaeis melanococca*) (cf. this BULLETIN, 1914, **12**, 237; 1916, **14**, 8; 1917, **15**, 38; 1919, **17**, 186).

The author states that all former reports on the aouara palm of French Guiana have described this palm as being *Astrocaryum vulgare*, but he considers that probably it is really *A. aculeatum*. From the pulp of aouara fruits the natives of French Guiana prepare a beverage and also extract the oil. This pulp gives on extraction with carbon bisulphide, a yield of 41·6 per cent. of a reddish-brown oil with an agreeable odour and a sweet taste. The kernels also yield a fat, known as "quioquio" or "thiothio," which resembles that extracted from "tucum" kernels, (*A. vulgare*).

"Mocaja," or "mbocaya," is the name given by the natives of South America to palms belonging to the genus *Acrocomia*. *A. sclerocarpa* is found chiefly in the region of the Amazon, while the species that predominates in Paraguay is *A. Totai*. It is therefore suggested that Paraguay kernels, which are generally stated to be derived from *A. sclerocarpa*, are actually obtained from *A. Totai* (cf. this BULLETIN, 1917, **15**, 38). *A. aculeata*, the "glou-glou" of the West Indies, is often confounded with *A. sclerocarpa*. The kernels of the former variety are less rich in oil than Paraguay kernels, while the oil has a lower iodine value.

The fruits of *Oenocarpus* sp. are used in Brazil and the Guianas for the preparation of beverages, while from the pulp an oil is obtained. *Oe. Bacaba* furnishes an oil known as "coumou oil," which is sometimes described as being obtained from the kernels, but which is really prepared from the pulp. The kernels contain only 1·3 per cent. of oil. This palm occurs in the region of the Upper Amazon. *Oe. Bataua* also furnishes an oil from its pulp.

Euterpe oleracea is known as "assahy" or "gissara" in Brazil and as "pinot" in French Guiana. Its fruits are used for the preparation of a beverage, while from the pulp is extracted an oil, named Para oil. According to one authority "assahy" is *E. edulis*.

Heckel has ascribed one of the "maripa" palms to *Attalea spectabilis* in Guiana, although "maripa" is used in Brazil to designate several other palms. The pulp yields on extraction with carbon bisulphide 14–15 per cent. of a red, liquid oil, while from the kernels 56 per cent. of a solid white fat is obtained. This fat can be employed for the same purposes as that from Cohune kernels. A sample of these fruits, under the name of "curua," has

recently been examined at the Imperial Institute and found to give a yield of 3·3 per cent. of a semi-solid greenish fat from the pericarp and 65·3 per cent. of a soft pale cream-coloured fat from the kernels, both these figures being expressed on the moisture-free material. The constants of the kernel oil were very similar to those for Cohune kernel oil (cf. this BULLETIN, 1920, **18**, 172).

Jumelle doubts the statement of the Imperial Institute that babassu nuts are derived from an *Attalea* sp., possibly *A. funifera*, and suggests that they are the product of *Orbignia speciosa*, to which palm the native name of "babaçu" is generally applied in Brazil. He states that the babassu kernels examined at the Imperial Institute compare very favourably in size with those of this palm, but admits that the babassu fruits of the Institute are much smaller than those of *O. speciosa*. On the whole the evidence brought forward seems insufficient to affect the generally accepted view that babassu kernels are derived from a species of *Attalea*.

Orbignia speciosa, the "ua-uaçu" or "babaçu" of Brazil, is described as one of the most beautiful palms of that country. Its fruits grow sometimes to the size of coconuts. It is estimated that one tree yields on an average 450 kilos. of fresh fruits. The kernels contain 60 per cent. of oil.

Candle Nuts.—The candle-nut tree (*Aleurites triloba*) grows in abundance on all the volcanic islands of the Pacific Ocean. At present the nuts are not collected, and large quantities consequently are lost every year. In view of the considerable demand for candle-nut oil, especially in the United States, it is suggested that this source of supply of the nuts should be exploited commercially (*Bull. Agence Gen. Col.*, 1920, **13**, 846; cf. also this BULLETIN, 1919, **17**, 591).

Coconuts.—A disease of the coconut palm is described in the *Tropical Agriculturist* (1920, **55**, 106), which is characterised by the breaking of the leaves and was first reported from Kurunegala, Ceylon, in 1918. The disease commonly starts at a terminal leaflet of one of the older leaves, the leaflet then withering and turning brown. At the base of the dead leaflet on the mid-rib is a dark brown discoloured area which extends along the petiole as the disease advances and later turns black. The disease extends rapidly, pairs of leaflets being killed in succession as the discoloured area progresses along the mid-rib. Eventually the leaf breaks, usually about the middle, and the withered end hangs downwards. Cultures made at Peradeniya with material obtained

from the junction of diseased and healthy tissues of the petiole in every case developed a fungus which proved to be a species of *Botryodiplodia*: as no other fungus developed in the cultures, it is considered that this fungus is the cause of the disease. Species belonging to this genus also cause the disease known as "die-back" on Hevea and cocoa and cause considerable damage to other plants, such as tea and sugar-cane. The fungus usually attacks palms of low vitality and those which have been previously infected by other diseases, and the result of the attack may be serious if the disease is left untreated. Remedial measures should be taken as soon as the attack is noticed. These should consist in cutting off the diseased portions of the leaf and burning them on the spot. The leaf-stalk should be cut at least 8 inches from the proximal end of the brown area to ensure cutting at a point beyond the limit of the diseased tissue, for the disease advances more rapidly in the interior of the petiole than at the surface. As trees of low vitality are most liable to attack, such details as drainage, manuring and cultivation should receive careful attention. This leaf-break disease is most likely to occur where *Pestalozzia* or other leaf disease is prevalent. In these cases spraying the palms with Bordeaux mixture may be found necessary as a preventive.

Ground Nuts.—According to the *Bull. Mat. Grasses, Marseille* (1920, No. 4, p. 196), 314,000 tons of ground nuts were produced in Senegal in 1919. The production is increasing so greatly that it is no longer possible to ship all the crop during the dry season, and it has been found necessary to erect storage sheds in which the nuts are protected from the wet, so that they may be shipped during the rainy season also. Owing to the high price realised by the crop, cultivators migrate from the Sudan to Senegal to grow ground nuts and depart immediately after the harvest.

Oil Palm.—In 1919, 69,000 tons of palm kernels and 22,000 tons of palm oil were exported from Dahomey, against 26,000 tons and 8,000 tons respectively in the previous year (*Bull. Mat. Grasses, Marseille*, 1920, No. 4, p. 196). Of these quantities 70 per cent. of the oil and about 23 per cent. of the kernels went to France, England and the Netherlands absorbing the bulk of the kernels.

Miscellaneous.—The results of the investigation of the nuts of *Hyphaene Shatan* ("satranamira") and of *Borassus madagascariensis* ("dimaka") from Madagascar are published in the *Annales du Musée Colonial de Marseille* (1919,

7, ser. 3, 100). From the former nuts, on extraction with ether, a yield of 8·1 per cent. of a pale yellow, liquid oil is obtained. This oil, after standing for a time, sets to a mass with the consistency of butter. From the "dimaka" nuts only a trace of oil (0·5 per cent.) can be obtained on extraction with ether.

Rubber

Hevea brasiliensis

Change-over Tapping.—Experiments have been carried out in Ceylon over a period of five years on the "change-over" system of tapping, in which tapping is periodically transferred from one side of the tree to the other, with the idea of securing increased yields, and also of obtaining better bark renewal by resting each side at intervals instead of tapping continuously. The results are recorded in *Bulletin No.* 47, 1920, *Dept. Agric., Ceylon.* In the first series of experiments the trees were tapped on alternate days by a single cut to the left at a height of 15 inches on one quarter. In one group the trees were tapped continuously on one quarter, the tapping being then transferred to the opposite quarter, and subsequently to each of the intermediate quarters in succession. In the other group tapping was transferred from one quarter to the opposite quarter every three months until two opposite quarters had been tapped completely, when the two remaining quarters were similarly tapped. In the second series the trees were tapped with a V cut on half the circumference at 3 feet from the ground. In one group tapping was continued down one side until 18 inches of bark had been removed, after which the other side of the tree was similarly treated. In the other group tapping was transferred to the other side of the tree every three months. Tapping took place on alternate days as in the first series. Details of tapping and monthly yields are given, from which the following conclusions are drawn: (1) a slightly increased yield was obtained by change-over tapping when tapping on quarters, but no increase when tapping on halves; (2) six months after tapping, bark renewal was better in change-over than in continuous tapping on quarters, but there was no difference in the case of tapping on halves; (3) the weight of rubber obtained from a given volume of latex is, on the average, the same whether the tapping is continuous or change-over.

Spontaneous Coagulation.—The results of investigations at Buitenzorg to determine the accelerating effect of

soluble lime salts on the spontaneous coagulation of Hevea latex in the absence of air are recorded in *Arch. Rubber Cultuur, Ned.-Ind.* (1920, **4**, 273). It was found that 0·5 to 1·0 gram of calcium chloride per litre of latex caused complete coagulation in closed vessels within twenty-four hours, a result in agreement with the previous work of Barrowcliff. Latex obtained during the wintering of the trees in the months of July and August exhibited a reluctance to coagulate. It did not coagulate completely in twenty-four hours in the absence of calcium chloride, but when this was present complete coagulation was effected within that time. The results in this section of the work indicate a close relation between wintering and the completeness of coagulation under these conditions. Vulcanisation tests with rubber prepared with lime salts showed the influence of the coagulant on the properties of the finished rubber to be negligible. In common with rubber prepared by spontaneous coagulation with other agents, the time of cure was less than that of rubber prepared by coagulation with acetic acid. The ash content of rubber prepared with lime salts was slightly higher than that of rubber coagulated with acetic acid, but no harmful influence could be traced to the ash constituents.

Further experiments on spontaneous coagulation in the presence of air are recorded on page 308 of the same *Archief* in comparison with the results already published on coagulation in the absence of air, including experiments on the effect of sugar as an accelerating agent. The last-mentioned method has been found by many investigators to be much more satisfactory than spontaneous coagulation in the presence of air without addition of accelerants.

The first series of experiments now recorded gave the following proportionate average yields of air-dry crêpe: latex coagulated with acetic acid and crêped next day, 100·0; latex spontaneously coagulated in the presence of air and crêped after two days, 98·8; latex to which 3 grams of sugar per litre had been added, coagulated spontaneously in the presence of air and crêped next day, 100·0; latex coagulated spontaneously in the absence of air and crêped next day, 99·5. The tensile strength and slope of the vulcanised products were practically the same, and were satisfactory for all samples. The time required for vulcanisation was least in the case of the latex spontaneously coagulated in the presence of air, and greatest in the case of the latex coagulated with acetic acid, whilst the latex spontaneously coagulated in the presence of air with sugar as an accelerant and the latex coagulated in absence of air required equal time to cure, and less than the

latex coagulated by acetic acid, the proportionate time being 91, 106, 102·5 and 102·5 respectively.

In a further series of experiments it was shown that heavy tapping causes a diminution in the latex of those substances which play an important part in the process of spontaneous coagulation, coagulation becoming slower and less complete. It is suggested that the sugars of the latex are the influencing factor in this case. The substances, however, that have an influence on the rate of cure, decomposition bodies formed by maturation, are not sufficiently affected by heavy tapping for the effect to be noticeable in the properties of the spontaneously coagulated rubber, light and heavy tapping giving the same rate of cure.

Hevea confusa.

A note on the rubber of this species of *Hevea* is contained in *Agric. Bull. F.M.S.* (1919, **7**, 366). The percentage composition of the rubber was: ash 1·00; resin 1·90; proteins 2·20; caoutchouc 94·90; which shows that the resin content, which is low, is not responsible for the soft, tacky and non-resilient character of the rubber. On keeping for some time the soft rubber of this species is stated to gain resiliency very slowly and finally resembles very inferior rubber from *H. brasiliensis*. *H. confusa* has proved to be a most objectionable tree, cross-fertilisation with *H. brasiliensis* readily taking place, and in the Guianas it appears to be the forestal host plant of the organism giving rise to the leaf disease of Para rubber, which has practically put an end to the chances of successful Para rubber cultivation in French and British Guiana.

FIBRES

Flax.—It is reported in the *Monthly Bulletin of Agricultural Statistics, Canada* (1920, **13**, 165) that the area devoted to flax in Canada in 1919 amounted to 20,262 acres, comprising 19,262 acres in Ontario, 800 acres in Quebec and 200 acres in Manitoba. The average yield of clean fibre per acre was 218 lb., and, although this compares unfavourably with the yield of 310 lb. per acre obtained in 1918, the quality of the flax was more uniform.

There are about 32 flax scutching mills in Canada, of which all but one are in Ontario, and these mills manufacture yarn, tow and other products from the Canadian-grown fibre. Efforts are being made to establish an industry for manufacturing linen and other flax fabrics, but difficulty is being experienced in obtaining the necessary

machinery. It is considered that the establishment of the flax industry in all its branches is very desirable, and at present prices should prove remunerative both to growers and manufacturers.

The area planted with flax in 1920 is stated to be 31,300 acres, and there appears to be every prospect of a good crop of both fibre and seed.

The Department of Agriculture have provided for the inspection and grading of the flax seed in order to ensure the maintenance of a uniform standard of purity and quality for the seed exported to Ireland. The production of flax seed for export is a new industry inaugurated during the war, and during 1919 there were 90,000 bushels of inspected seed shipped to Ireland.

Paper-making Materials.—*Spent Wattle Bark.*—In this BULLETIN (1917, **15**, 500) an account has been given of experiments carried out at the Imperial Institute with the spent wattle bark remaining after the use of the bark for tanning or for the preparation of extract, and it is shown that this material is suitable for use as a source of pulp for the production of wrapping paper, and could probably also be employed for the manufacture of the cheaper grades of white or cream paper. In the *South African Journal of Industries* (1920, **3**, 615) it is stated that a company is being formed in Maritzburg for the manufacture of paper from the spent wattle bark of the local tanning extract factories.

Papyrus.—According to the *U.S. Commerce Reports* (1920, No. 192, p. 802) a concession has been granted to a large company to work the papyrus which grows abundantly near Elizabethville in the Belgian Congo, principally along the lower Lualaba, near the lakes of Kabuli, Sjemba, Kisali and Neaga. A factory is to be established near the river which will have an initial production of 20,000 tons of pulp per annum. It is stated that the papyrus of this region yields 37·8 per cent. of pulp and that a satisfactory process for bleaching the pulp has been devised.

It is reported in the *South African Journal of Industries* (1920, **3**, 615) that a factory has been established at Mill Halt, Zululand, for the production of pulp from the South African papyrus for export.

Florida Saw Grass.—A statement is made in the *Paper Maker* (1920, **60**, 498) that a company is being organised in the United States, under the name of the Grass Pulp and Paper Corporation, for the production of paper pulp from the Florida saw grass. Experiments which have been carried on for four years are said to

have resulted in the manufacture of a better grade of newsprint paper from this native grass than is made from spruce wood-pulp. The company hope to establish shortly their first mill in Florida and subsequently to erect nine more in various parts of the country. There are hundreds of thousands of acres of saw grass in Florida, and the company consider that they have enough raw material under their control to supply a large number of mills.

Palmyra Palm Leaves.—An account of a study of the leaves of *Borassus flabellifer* (the palmyra, ronier or talipot palm) as a possible paper-making material has been given by Prof. F. Heim (in collaboration with MM. J. Maheu and L. Matrod) in the *Bulletin de l'Agence Générale des Colonies* (1920, **13**, 801).

The leaf-blade yielded, on chemical analysis, 5·34 per cent. of ash, composed of iron, lime and silica, 52·2 per cent of cellulose, 41·6 per cent. of lignone and a very small quantity of wax-like substances. On digestion with soda under pressure it gave a yield of about 28·30 per cent. of pulp. This pulp was of a brown colour and proved difficult to bleach; on microscopical examination it was found to have a satisfactory felting power and to contain a fairly large number of pitted and reticulated cells together with fibres about 4 mm. in average length and 30–40 μ in diameter. The leaf-blades are somewhat difficult to disintegrate completely by soda treatment, and the digestion must not be carried too far or the solidity and firmness of the product will be reduced. The paper produced from the bleached pulp was of a yellowish colour and possessed a very satisfactory resistance to rubbing and an average resistance to tearing, but was rather weak to direct pulling.

The petiole, or leaf-stalk, yielded 1·75 per cent. of ash, composed of the same constituents as that of the blade, 0·87 per cent. of fats and waxes, 53·6 per cent. of cellulose, and 41·6 per cent. of lignone. Technical trials made by digestion with soda showed that the petiole required somewhat severe treatment to effect its reduction and furnished 29 per cent. of pale coloured pulp. On bleaching, this pulp gave 93·7 per cent. of its weight of the bleached material. The bleached pulp gave a greyish paper, soft to the touch, and still containing some incompletely disintegrated tissue. This paper was more flexible than that obtained from the leaf-blades, and offered a fairly satisfactory resistance to pulling, tearing and rubbing. Microscopical investigation showed that the characters of this pulp are almost the same as those of the pulp from the leaf-blade, but that it contains a large proportion of spiral and annular vessels. This fact, together with the poorer

felting power of the pulp (0·011 as compared with 0·008) explains the poorer resistance of the paper. The ultimate fibres have an average length of 4·2 mm. and an average diameter of 35 μ. The petiole appears rather more difficult to treat than the leaf-blade and to furnish a somewhat less resistant pulp, but, in general, the two parts of the leaf are so similar that in the case of their industrial utilisation they should be treated together.

On the whole, it is considered that the palmyra palm-leaf is a raw material of average value and capable of being obtained in regular supply for use in paper-making.

Cotton

In connection with the organisation of the work of the Empire Cotton Growing Committee, it has been realised that close touch must be maintained between the Committee and the Governments of those British countries in which cotton growing might profitably be developed, and that accurate information is needed as to local conditions.

The Committee have therefore appointed Sir Hector Duff, K.B.E., C.M.G., formerly Chief Secretary to the Government of Nyasaland, to undertake a mission to Nigeria, and Major H. Hastings Horne, C.B.E., to carry out similar work in Tanganyika (formerly German East Africa). Major Horne was for some time in the service of the Government of East Africa Protectorate and more recently Political Officer in Tanganyika.

The work of the British Cotton Growing Association has proved that Nigeria offers great possibilities for the extension of cotton growing, and Sir Hector Duff has therefore been asked to report as to the means by which the industry could most successfully be developed.

Similarly the existence of facilities for creating a large cotton-growing industry in Tanganyika was demonstrated during the German occupation of that country. Major Horne has now been entrusted with the task of ascertaining the present position of the industry and its future prospects, and with this object in view he sailed for Africa in October 1920.

Boll Weevil.—A report on "Cotton Boll Weevil Control by the Use of Poison," by B. R. Coad and T. P. Cassidy, has recently been published as *Bulletin No.* 875, 1920, *U.S. Dept. Agric.* It is pointed out that in applying poison for the control of the boll weevil, the extermination of the pest is neither attempted nor effected, but the object of the

treatment is to secure such a reduction of numbers as to enable a full crop of cotton to be secured. The cotton plant always produces many more fruits than can be brought to maturity, and about 60 per cent. of them are normally shed, especially those which appear at a comparatively late period. It has been found that up to a certain point the shedding of the fruit owing to boll weevil attack merely takes the place of the normal shedding which would occur even in the absence of weevils.

The system of poisoning now in use is only intended to reduce the weevil infestation to such an extent that the weevils will not cause the shedding of more bolls than would normally occur. The weevils are therefore allowed to multiply until they have become sufficiently abundant to puncture more fruits than would be shed normally. Poisoning is then started with a view to keeping the infestation below this point until the plants have developed as many bolls as they will be able to mature. Large increases in yield often result from adoption of a slight degree of control for a short time during this critical period.

The poison recommended for this purpose is powdered calcium arsenate. When this was first used it was found to cause injury to the foliage. This was due to the excessive amount of water-soluble arsenic present, but calcium arsenate is now prepared which is free from this defect, and should conform to the following specification: arsenic pentoxide, not less than 40 per cent.; water-soluble arsenic pentoxide, not more than 0·75 per cent.; density, not less than 80 or more than 100 cubic inches per lb. The conditions specified with reference to the density are of importance, as, if the product is too heavy, it is not suitable for use in dry powdered form and will not produce the proper type of dust-cloud to cover the cotton plants thoroughly, whilst if it is too light it is blown away from the plants too rapidly by light breezes.

Information is given as to the precautions to be observed in order to avoid danger to the labourers and mules engaged in the poisoning operations or to live-stock in neighbouring pastures. Full particulars are also supplied of the conditions under which the applications should be made, the intervals between successive applications, and the number of times the poison should be applied. The best time for distributing the poison is when the humidity is high, the air calm, and the plants are moist with dew, so that the dust will adhere readily. These conditions are generally experienced only at night, so that it is necessary to apply the poison between the late evening and early morning.

Reference is made to the organisation of poisoning operations, and a full account is given of the different forms of machinery designed to ensure thorough distribution. The cost of the poisoning and the gains to be expected from it are also discussed.

Interesting information on the poisoning of the boll weevil is also given in the *Experiment Station Record, U.S. Dept. Agric.* (1920, **43**, 162) in the form of an abstract of a report in *Journ. Econ. Ent.* (1920, **13**, 123) of an investigation to determine whether the presence of dew or rain-water on cotton plants is necessary to the effective use of arsenates. It was found that the destruction of boll weevils on plants treated with lead and calcium arsenates and protected from rain and dew was greater than that on plants similarly treated but exposed to dew and rain. It is evident, therefore, that the effect of either poison is brought about by the ingestion of the poison with the weevils' food and not by drinking the so-called "poisoned dew." The following conclusions were drawn from this work: "As the boll weevil is poisoned largely or entirely through taking poison with its food, machinery for applying the poison to the cotton plants should be so designed as to apply the poison primarily to the squares, bolls and terminal buds rather than to the foliage. The greatest mortality among the boll weevils occurred on the third day following the application of the arsenates and fell off rapidly after the seventh day, indicating that, other things being equal, application should be at intervals of a week or less apart."

FORESTRY AND FOREST PRODUCTS

Woods from East Madagascar.—Prof. Perrot, of the Paris École Supérieure de Pharmacie, has started a valuable series of researches by his students into the woods of French colonies. The description of each species is tabulated on a uniform system in a schedule giving general external characters of bark and wood, density, ash-proportion, etc., and the microscopic characters under a magnification of 50 diameters, the measurements of all the elements being given in micro-millimetres from transverse and tangential sections. This schedule is accompanied in each case by two schematic diagrams, one for each section, similar to those familiar to wood-students in Moll and Janssonius's *Mikrographie*. In the volume of *Travaux du Laboratoire de Matière Médicale* of the school for 1917–19, M. André Gérard describes on these lines thirty-eight woods from the montane region of Eastern Madagascar,

together with eight common European woods for comparison. In a short account which he gives of the distribution of forest in the island there are stated to be more than 150 species of trees in the region, all allied to the evergreen equatorial forest of the oriental region. The native name " Hazomafana " appears to be applied to two timbers, viz. (1) *Diospyros megasepala*, Baker, apparently a perishable white wood of no value as timber and quite unlike other species of *Diospyros*, which yield ebony; and (2) the more valuable *Erythroxylum myrtoides*, Bojer, which is, it would seem, the wood usually exported as " Hazomainty." The author groups the woods he describes into five classes according to the distribution of wood-parenchyma as seen with a lens on a transverse section.

The Growing of Mine-props on the High Veld.—An article by K. A. Carlson, Forest Conservator in the Transvaal, in the *Journ. Dept. Agric., Un. S. Africa* (1920, **1**, 261), discusses the growing of the five species of *Eucalyptus* most suitable for mine-props, viz. *E. viminalis*, *E. rostrata*, *E. Maidenii*, *E. globulus* and *E. sideroxylon*. As most of the mine-timbering is only required to last a few years, durability is not essential; but, should the demand for props decline, such a wood as *E. rostrata* is more suitable for other purposes than *E. viminalis*; but, whilst *E. viminalis* and *E. Maidenii* are estimated to be ready for final felling in twelve to fifteen years, *E. rostrata* and *E. sideroxylon* may take five years longer to attain prop size. With such adverse influences as droughts, frosts and cold winds, planting and supervision from start to finish obviously require considerable care and skill to yield a profitable crop.

Experiments with Timber Trees in Rhodesia.—J. S. Henkel, a Forest Officer in Rhodesia, gives (*Rhodesia Agric. Journ.*, 1920, **17**, 335) an enumeration of exotic timber trees planted in Umtali Park, Southern Rhodesia. Fourteen species of *Eucalyptus* are represented, the best of which appear to be *E. paniculata*, grey or white ironbark, described by Maiden as " the king of New South Wales hardwoods," and *E. maculata*, the spotted gum. Some Australian acacias are mentioned, whilst toon (*Cedrela Toona*), camphor and some others are, rather unusually, classed among soft woods with several cypresses and five pines. The best growth among these has been that of the Himalayan chir, *Pinus longifolia*, 55 feet in height and with a diameter mostly of 7, 8 or more inches, up to 11 inches in 18 years. As the earliest trees were planted in 1897, the experiment is as yet not very far advanced.

Conservation of Tuart.—According to the *Australian Forestry Journal* (1920, **3**, 143) the Western Australian Forest Department has repurchased certain properties in the very limited area between Perth and Geographe Bay which produces the valuable tuart or white gum (*Eucalyptus gomphocephala*), and these have now been dedicated as tuart reserves in perpetuity. Tuart, though too heavy for ordinary use, is one of the strongest and toughest of known timbers. It is at present mostly employed by the West Australian Railway Department for the frames and undercarriages of railway wagons; but it has also been recommended for dock-gates, piles, woodwork in engine rooms, capstans, the naves of wheels, etc.

Forestry in Victoria.—H. Mackay, Commissioner for Forests, Victoria, has contributed a series of five papers on this subject to the *Australian Forestry Journal* (1920, **3**, 116, 147, 179, 212, 246). With a total area of nearly 56,250,000 acres, there are about 12,000,000 acres of woodland, of which only some 500,000 acres are being cut, and the bulk of the forest revenue is derived from about 250,000 acres, which are being felled for mine-props and fuel. Much valuable timber has been recklessly felled or burnt by settlers; but with the restriction of forest fires considerable areas are naturally regenerating themselves, though often with inferior stringy-barks. Sheep devour seedlings and young stool shoots, even when grass is abundant, and much valuable young forest growth is sacrificed for a small grazing revenue. Good reserves of red gum, box and ironbark are available for railway sleepers, and blackwood and evergreen beech for cabinet work still exist in Otway Peninsula, Gippsland and Wilson's Promontory. Victoria possesses some twenty species of *Eucalyptus* of large size and high commercial value; but it is regrettable that the author refers to the trees only by their vernacular names, the application of which is notoriously local and variable. The various methods of exploiting the existing timber are discussed and an account is given of the State plantations at several centres, now totalling 10,000 acres. In these, the best results have been obtained with sugar gum and *Pinus insignis* (Monterey pine); but the mistakes of giving the conifers unnecessarily rich soil and planting them 12 feet apart have been made, whilst many useful species that might have been tried, such as Douglas fir, pitch and Corsican pines, Californian redwood, poplars, tulip-tree and basswood have, until the last few years, been neglected. The possibilities of these and other species in South-East

Australia are discussed practically from the point of view of the small settler, and the series of articles concludes with an account of the forest school for boys at the nursery and plantation at Creswick, near Ballarat.

MINERALS

Asbestos.—Hartwell Conder, in an interesting article on "Asbestos Mining in Australia" (*Chemical Engineering and Mining Review*, Melbourne, October 5, 1920, p. 7), points out that in the New England district of New South Wales chrysotile asbestos, chromite and magnetite are associated with serpentine along a great fault line, which extends north-west from a point 20 miles north of Tamworth, almost to Warialda, 100 miles away. The distribution of the fibre veins in the mother rock is most irregular and liable to sudden and total extinction, but on a larger scale and of greater frequency than is the case with the asbestos deposits of Beaconsfield, Tasmania, which had to be abandoned on account of their erratic nature.

A deposit is mined at Woodsreef, 10 miles east of Barraba. Over a dozen quarries have been opened up on one property, and connected by rail with the mill. The latter is driven by a powerful Diesel engine. The milling process adopted is based on Canadian practice. The rock is crushed with a jaw-breaker and rolls to the size of peas; the product is passed into a disintegrator or beater, which pulverises the brittle rock to sand and beats out the fibre into fluff. From this machine, the product is passed over shaking screens, at the lower end of which the mouth of a suction-tube is brought down close to the surface. The fluff is caught up by the air current, carried away and deposited in collecting bins.

According to B. Dunstan the veins, about 1 inch thick, are numerous and close together, and the fibre produced is superior to anything yet found in Queensland.

Bauxite.—An account of the bauxite deposits (aluminous laterite) of Western Australia is given by A. Gibb Maitland in *The Mining Handbook* (*Memoir No.* 1, 1919, *Geol. Surv., W. Austr.*).

The laterite at Smith's Mill, which extends eastward to Baker's Hill, 47 miles from Perth, was examined and reported on in 1902, and was further investigated in 1912. Since then 46 samples of bauxitic laterite from different portions of the Darling Range of mountains have been analysed in the Geological Survey Laboratory. The percentages of alumina, soluble in acids, were as follows: 45 to 50 (5 samples), 40 to 45 (6 samples), 35 to 40 (15

samples), under 35 (20 samples), the last being regarded as unprofitable. Those varieties which contain the highest percentage of acid-soluble alumina are composed of a light-coloured matrix, scattered throughout with nodules of brown iron hydrate or decomposed quartz rock about the size of peas. The laterites situated on the highest ground have so far proved to be richer in alumina than those at the lower levels. Partial analyses show that the percentage of ferric oxide varies from 9·79 to 45·14. Railway lines run through the region examined.

The deposit in the Wongan Hills, which are on a railway line 132 miles from Perth, is a residual one and has evidently been formed *in situ.* It is extensive, and analysis has shown that the bauxite contains 44·66 per cent. of alumina.

A very large area of laterite, up to 20 feet in thickness, occurs at Greenbushes, on a railway line, 159 miles south of Perth. Analysis has shown the presence of from 25·62 to 33·24 per cent. of alumina, and from 18·82 to 35·50 per cent. of ferric oxide. Gibbsite (Al_2O_3, $2H_2O$) is the most important constituent next to ferric oxide: it contains iron sesquioxide as an impurity in variable amount, sometimes exceeding that of the alumina.

The value of the Western Australian bauxite deposits is difficult to estimate, but it is considered that they might be developed by (1) exporting the raw material for use in aluminium factories; (2) manufacturing pure alumina locally for export to aluminium works; or (3) manufacturing the metal in the State. The second scheme would appear to be the most practicable, and need not involve any heavy outlay of capital.

Chromite.—According to *South African Engineering*, April 1920, chromite mining has recently been commenced on the farm Jachtlust, Ward Steelpoort, Lydenburg district, Transvaal. The farm is 50 miles south-east of Pietersburg, and the projected railway line from Middelburg to Pietersburg should pass fairly close to the property. Two samples of chromite, said to have been obtained from near Jachtlust, were sent to the Imperial Institute for analysis in 1908. These samples were apparently not pure chromite, having admixtures of pyroxene and felspar. First quality ore gave, on analysis, chromic oxide 47·0 and ferrous oxide 24·0 per cent., and second quality ore, chromic oxide 38·4 and ferrous oxide 21·5 per cent.

Chromite occurs at Jachtlust in the form of a lode, 6 feet in thickness, which has been traced for a considerable distance. Associated with the chromite are extensive masses of magnesite. The deposit is stated to be the finest

and most extensive body of chromite known in the Transvaal. There is abundant water and wood for fuel—but not for timbering—on the property. It has been estimated that the costs per ton delivered, f.o.r. Pietersburg, will be 21*s.* 3*d.* per ton, and the selling price there should be 35*s.*, leaving a profit of 13*s.* 9*d.* per ton.

Diamonds.—The discovery of diamonds early in 1919 by A. E. Kitson, Director of the Geological Survey, Gold Coast, at Abomoso, north-west of Kibbi in Eastern Akim, has now been followed up by commercial activity. According to the *African World* (April 24, 1920) a concession covering an area of 20 sq. miles has been acquired by the Akim Diamond Fields, Ltd., a subsidiary company of the Goldfields of Eastern Akim. Just previous to the formation of the company 500 small diamonds were found in three weeks' prospecting, by panning only, and as many as 7 diamonds were found in one pan of gravel.

From the account given by Kitson in his *Report on the Discovery of Diamonds at Abomoso* (*Geol. Survey, Gold Coast*, Accra, 1919), it seems probable that a diamantiferous gravel deposit of great importance exists.

Diamonds were traced over a length of 1½ miles along the Abomo stream, some were found in the low ridge to the east of it, and also in the old bed of the Birrim River, near Abomoso, and, by panning, about 600 diamonds of small size were obtained in 17 days, the largest weighing ⅛ carat. Many of the gems were in perfect crystals, colourless and transparent, the commonest forms being the octahedron and the rhombic dodecahedron. The gravel containing the diamonds is usually coarse, with a good deal of quartz. The concentrate is scanty, consisting of quartz, topaz, zircon, black sand (undetermined), a little red garnet, brown corundum, ragged and partially worn gold (coarse and fine), odd fragments of rutile and black tourmaline and numerous small elliptical crystals (undetermined) of pale bluish colour, but white when bleached. The bedrock proved in some cases to be decomposed phyllites (altered slates), in others a decomposed volcanic rock with chlorite or tuffs ; all of which belong to the Birrim series. Kitson thinks that the general character of the diamantiferous gravel and the concentrate therefrom suggests the derivation from a granite-pegmatite area.

An account of the diamond-bearing deposits in the Hay and Gordonia districts, Griqualand West, Cape Province, is given in the *S. Afric. Min. and Engin. Journ.*, Feb. 28, April 10, and May 8, 1920. A belt of diamantiferous country in these districts is traceable for a length of 40 miles and

a breadth of 20 miles. The village of Postmas is near the middle of the belt, and is situated 120 miles west of Kimberley and 40 miles from Griquatown.

The Ongeliek volcanic group of the Griquatown Series forms the geological horizon of the extreme northern and southern sections, and is, for the most part, overlain by surface alluvials. The central and north-western areas are covered by the dolomite limestone and cherts of the Campbell Rand Series, and in part by superficial deposits. The country is traversed by well-marked dolerite dykes of the Karroo type, striking principally in a north-easterly direction. Kimberlite occurrences have long been known to exist in this area, the Peiser Mine pipe towards the south having been discovered many years ago, while the Makganyen Mine is a more recent discovery. Quite recently important diamantiferous discoveries have been made, notably at the West End and the Postmas Diamond Prospects. The latter property consists of two mines. On No. 1 mine, kimberlite has been proved for 40 claims in length (E.–W.) and 6 claims in breadth (N.–S.). Some diamonds of good quality have been found in the "yellow" (15 stones equal to 8½ carats from 45 loads). On Mine No. 2 yellow kimberlite has also been met with. A true kimberlite pipe has also been proved to exist on the West End Mine, a little over a mile distant from the last. Small test washings have given as much as 38 carats per 100 loads. The diamonds of the region are said to be of exceptional brilliance and purity.

Other properties in this region extend along the belts of hæmatite and kimberlite breccias from near Griquatown to more than 30 miles north-north-west at Postmasburg. Over a large part of this area indications of diamond-bearing deposits have already been found, and in certain localities important discoveries have been made. Prospecting operations have been in progress since June 1919, and are now being conducted on a large scale. The Makganyen mine, already mentioned, which lies 17 miles north-north-west of Postmasburg, has yielded fine quality diamonds, and is now equipped with a new plant of about 150 loads per day capacity. On the farm Kouwater, 3 miles north-north-east of the last mine, a kimberlite pipe, which promises to be of large dimensions, is being explored. The kimberlite breccia ("yellow") is rich in mica and garnets and all the mineral constituents accessory to diamantiferous pipes. From Makganyen No. 2 to the east of Kouwater, a few diamonds have been recovered, and at Waterstroomvlei, 12 miles south of Postmasburg, in the Ongeluk volcanic series, three small diamonds have been

found in a kimberlite occurrence, together with grossularite garnets, olivine and " carbons."

Some rich diamond-bearing gravel has been washed recently at Rouxville, situated about 150 miles south-east of Kimberley, in the Orange River Colony (*S. Afric. Min. and Engin. Journ.*, Oct. 9, 1920, p. 97). The main diamond deposit, located on the Klipfontein farm, is described as a pot-hole, caused by the scouring action of a river flowing over a dyke, and filled with various breccias, gravels and conglomerates. The surface area of the deposit is 70,307 square feet, and the depth is 50 feet. Commencing at the surface, the following layers occur: (1) overburden of sandy light gravels, 25 feet; (2) brown boulders and gravel, 5 feet; (3) light sandy conglomerate, 5 feet; (4) brown boulders and gravel, 5 feet; (5) brown gravels, 6 feet; (6) black conglomerate, 4 feet; (7) red shade (floor). The total estimated contents, not including (1), are 45,860 loads. The yield from certain portions of the black conglomerate has been phenomenally rich, and the diamonds obtained are of a very fine average quality. In a test washing, 35 loads yielded 49 diamonds with a total weight of 250 carats, their estimated value being £8,700. Three of the stones weighed 56, 26 and 21 carats respectively. From 2,269 loads, made up of 1,142 loads of " dumps," 575 loads of " surface gravels " and 552 loads from the remaining layers, 796 diamonds were recovered; the weight of these was 1,282¾ carats, and their estimated value £21,698.

Molybdenite.—Queensland has in recent years produced as much as two-thirds of the world's output of molybdenite. The ore occurs in several localities in the State, the principal deposits being at Wolfram, Chillagoe mining field, North Queensland, and at Wonbah, in Central Queensland. An interesting account of the last-named mine is given by J. H. Reid in the *Engineering and Mining Journal* (Nov. 13, 1920, p. 947).

Wonbah lies 60 miles due east of Bundaberg in the heart of the Coastal Range. The exploitation of molybdenite began a few years ago, and in 1917 the mine reached the producing stage. The ore, like that at Wolfram, in North Queensland, is disseminated in a quartz pipe in granite. The Wonbah deposit is near the contact of the granite mass with Palæozoic slates and close to a dyke of quartz-porphyry. The pipe, which is almost cylindrical, varies from 42 to 60 feet in diameter from the surface to a depth of 200 feet and dips 75° fairly regularly, differing in this respect from the pipes of North Queensland, which are

noted for their irregularity. Calcite is somewhat abundant and, in the lower levels, small masses of chalcopyrite, pyrite, galena and blende have appeared. The outer zone only of the pipe is sufficiently rich in molybdenite to be worked. The ore consists of white milky quartz with flakes and masses of molybdenite. The base metals occur only as small segregations, and are discarded in mining.

The ore, as it goes to the mill, consists of molybdenite with quartz and some calcite (containing on an average 0·8 per cent. of molybdenite, MoS_2). The ore is crushed in a 10-head stamp-mill, of 1,000 lb. per head, running at 98 drops per minute, and is then passed through wire-woven screens with 625 holes per square inch. The pulp is then passed through a 12-inch unit oil-flotation plant. The pulp, after being thickened, is mixed with water, in the proportion of four of the latter to one of the former, and ½ lb. of eucalyptus oil per ton of pulp is automatically added, extremely small quantities of kerosene being added periodically to assist frothing. The initial treatment gives a concentrate of 70 per cent. molybdenite, but at the end of the month the whole of the concentrate is re-treated, bringing the grade up to 90 per cent.

In 1918 the mine produced 13·95 long tons of 90 per cent. molybdenite concentrate from 2,435 tons of crude ore, and in 1919 41·75 long tons of similar concentrate from 6,026 tons of crude ore.

Petroleum.—According to reports which have appeared in the technical press, oil has recently been struck in a well at Fort Norman, situated at the junction of the Great Bear and Mackenzie Rivers, at approximately 65° N. and 126° W. It appears that a little oil was encountered in the Devonian formation several times during the drilling of the well, but in October 1920, at a depth of 800 feet, oil flowed at the rate of 2,000 barrels per day, after which the well was shut in. The discovery is likely to lead to a greatly increased amount of exploration for oil in 1921. It is stated that a British undertaking will then explore in Western Canada, that several Canadian concerns will be in the field, and that the Metallurgical and Chemical Society of Billings, Montana, has practically completed arrangements for exploring the country north of the 70th parallel. The last-named exploration party will be equipped with motor-cars specially designed for ice and snow, hydroplanes, a wireless installation and a portable laboratory.

The region has been explored by Bosworth and other geologists, and, as the Devonian formation has been proved

to be of considerable extent and to show seepages of oil over a very wide area, it is thought by some of them that the territory may prove to be one of the most important oil-fields of the world. However, the region is a remote one, being upwards of 1,000 miles from the nearest railway, so that, unless a very large production is demonstrated by actual drilling, the cost of a pipe-line would prove prohibitive, and, in any case, the probabilities are that several years must elapse before oil can be produced in the North-West Territories in large quantities.

Phosphate Rock. *Ocean Island.*—This island lies in the Pacific, 52 miles south of the Equator, and forms part of the Gilbert Archipelago, east of New Guinea and the Solomon Islands. It is one of the greatest phosphate-producing islands of the world, and was discovered in 1804 by the English ship *Ocean.* The island is 6 miles in circumference and 1½ miles across, the area being 1,500 acres. This and other coral islands in the equatorial belt have been for ages rookeries of sea-birds, and the leachings from the guano have impregnated the coral limestone, forming phosphate rock. That the process of phosphatisation of the coral limestone has been slow and gradual, but ultimately complete, was shown by R. Dupont in his "Report on the Guano Deposits of Assumption Island, Seychelles," a summary of which appeared in this BULLETIN (1911, **9**, 39).

According to A. Stanley Ridley ("Ocean Island Phosphate Field," *Chemical Engineering and Mining Review*, Melbourne, August 1920), the phosphate in Ocean Island is mined from between the coral pinnacles, the deposits in some places being 70 feet deep. The phosphate is hard and requires the frequent use of explosives. Electrically-driven ropeways convey the material from the deeper deposits into the open ground, whence it is carried by locomotive-driven, side-tipping trucks to the drying plants. The phosphate is crushed before passing into the dryers. Each dryer is 21 feet long and 6 feet in diameter, and is rotated at 5½ revolutions per minute. The phosphate remains in the dryer 15 minutes only, by which time it has lost 10 per cent. of moisture. The dried phosphate is carried by conveyors and elevators to a bin, having a capacity of 24,000 tons, and built of reinforced concrete. There is a series of concrete tunnels underneath the bin, through and beyond which the phosphate is carried by various conveyors to the outer end of the wharf, which is of cantilever construction. Boats transport the phosphate to the ships which are moored to large buoys some distance from the shore.

There is a large power-house, all the machinery being electrically driven, a well-equipped machine-shop, etc. The annual output varies from 70,000 to 300,000 tons of rock carrying 85 per cent. of tricalcium phosphate.

Pleasant Island (or Nauru).—On this island in the same group, there are important phosphate deposits of similar origin to those of Ocean Island. They were briefly described in this BULLETIN (1915, **13**, 568). Pleasant and Ocean Islands were in possession of Germany before the war, and were exploited by the Pacific Phosphate Co., Ltd., on a royalty basis. The Governments of Great Britain, Australia and New Zealand will now work them conjointly, each of the first two receiving 42 per cent. and the last 16 per cent. of the profits. The amount payable to the Pacific Phosphate Co., Ltd., as compensation for its lost rights is £3,500,000 (*Chem. Eng. and Min. Review*, Aug. 5, 1920, p. 404). The quantity of phosphate available in Pleasant Island is enormous (probably from 80 to 100 million tons), and the quality is of the highest grade (85 to 86 per cent. of tricalcium phosphate). The average yearly production is 150,000 tons (*The Fertiliser and Feeding-stuffs Journal*, March 17, 1920, p. 212).

Agawi Island.—The phosphates which occur on this island, which is in the Dutch East Indies, have recently been examined and described by A. Wickmann. An analysis of a sample showed 68·9 per cent. of tricalcium phosphate, which is less than that usually found in the deposits of the South Sea Islands (*American Fertiliser*, April, 1920, p. 92).

United Kingdom.—It is well known that bands containing phosphatic nodules or "coprolites" occur in various rocks of the United Kingdom, for instance, in the Red and Coralline Crags (Pliocene), below the Chalk Marl, in the Gault and Lower Greensand, and even in Ordovician limestone, and that some of the bands were formerly worked on a fairly large scale. In 19 years, or from 1874 to 1892 inclusive, the output amounted to 1,170,552 tons, containing upwards of 50 per cent. of tricalcium phosphate. However, in 1893 there was a sudden drop in the production, owing to the importation of cheaper phosphates and to the utilisation of basic slag, and the industry gradually languished, becoming extinct in 1909.

Quite recently large deposits of phosphate have been located in the Peak district, Derbyshire. The deposits are said to be quite near the surface in many instances, the productive portion being 6 inches in thickness. The samples analysed yielded from 50 to 55 per cent. of phosphates (*Fertiliser and Feeding-stuffs Journal*, March 17,

1920, p. 214). In Cambridgeshire the productive part of the band was from 8 to 12 inches thick, and the cover of chalk marl varied from a few feet up to 20 feet in thickness.

Notwithstanding the thinness of overburden, it is doubtful whether the Peak deposits could be economically won under present conditions.

Pig Iron from Iron Pyrites.—Iron pyrites is utilised for the production of sulphur dioxide, which is used mainly in the manufacture of sulphuric acid. The by-product, resulting from roasting the ore, is classed as cinder, and consists of ferric oxide, the impurities of the original ore and some unaltered sulphides. The sulphur content may vary from 1 per cent. to more than 5 per cent. Should the cinder contain copper and the precious metals, it is usually submitted to a chloridising roasting, and the copper is then leached out with water and precipitated by iron scrap. The residues from the leaching form a nearly pure iron-ore, which, after sintering, may be utilised in a blast-furnace. Cinder containing iron oxide without copper, etc., can occasionally be used in iron furnaces, but the high content of sulphur has, in most cases, proved too deleterious for its use as an ore of iron. In the issue of the *Technique Moderne* for July 1920, M. Marcel Guédres gives a description of a process of manufacturing pig-iron from cinder in electric furnaces. The process depends mainly on: (1) the complete elimination of all moisture in the preliminary roasting, and (2) the desulphurising action of the electric furnace being increased by the addition of a calculated amount of calcium chloride to the molten bath. Should the process prove a commercial success, very large quantities of cinder, now thrown away, or used as ballast or road-dressing material, will become available for conversion into pig-iron.

NOTICES OF RECENT LITERATURE

THE SUGAR-BEET IN AMERICA. By F. S. Harris, Ph.D. Pp. xviii + 342, Crown 8vo. (New York: The Macmillan Company, 1919.) Price 12*s*. net.

This volume is a welcome addition to *The Rural Science Series*, edited by L. H. Bailey. Although much has been published in the past in the *Bulletins* and *Reports* of Experiment Stations and the Department of Agriculture in the United States on the various aspects of the cultivation of the sugar-beet in America, this is the first connected account of the whole subject that has appeared. The quantity of beet-sugar produced in the United States is

still far below the pre-war production of Germany, Russia and Austria-Hungary, and is about equal to that produced in France before her factories were partially destroyed during the war, the maximum production, chiefly refined sugar, being 874,220 short tons in 1915–16. Nevertheless, the output of beet-sugar has increased rapidly during the last twenty years, and the information as to the methods employed in the industry which is given in this book will be of great value not only to farmers in America, but in all countries where the cultivation of the sugar-beet is being undertaken.

An account is given of the development of the beet-sugar industry in the United States, and particulars are furnished of the characters of the sugar-beet, the climatic and other conditions required for its cultivation, and also of the soils, manuring and rotations suitable to the crop. It is advisable, as a rule, for the farmer, before the crop is sown, to enter into a contract with the sugar factory regarding the purchase of the roots; for the guidance of the farmer, the author gives sample contracts of various types, including some relating to the supply of labour for thinning, hoeing and digging, in accordance with a system which is in vogue in some places. Full information is given regarding the preparation of the seed-bed, planting, thinning, irrigation, drainage, harvesting, pests and diseases and the production of seed for sowing. The author also discusses the community aspects of sugar growing, the utilisation of by-products and the world's sugar supply. A chapter is devoted to a brief outline of the cultivation of the sugar-cane and a concise account is given of the methods of sugar manufacture. A bibliography, containing nearly 300 entries, is appended to the book, and other appendixes relate to details of American beet-sugar companies and factories in existence in January 1918, and to useful statistics of the production of beet-cane and sugar in various countries. The book is well illustrated by numerous diagrams and reproductions of photographs.

THE MANUFACTURE OF SUGAR FROM THE CANE AND BEET. By T. H. P. Heriot, F.I.C., Lecturer on Sugar at the Royal Technical College, Glasgow. Pp. xi + 426, with illustrations, Demy 8vo. (London: Longmans, Green & Co., 1920.) Price 24s. net.

In this book a concise account is given of the extraction, manufacture and refining of cane and beet-sugar, and an endeavour has been made to correlate the methods of treatment with the scientific principles on which these methods are based.

The first part deals with the raw materials of the industry, reference being made not only to the sugar-cane and beet but also to other sugar-yielding plants, including sorghum, maize, sugar maple and the various sugar palms. The various processes involved in the extraction of the juice and its subsequent treatment and evaporation and in the crystallisation and refining of the sugar are clearly described, and numerous illustrations are given of the plant and machinery employed.

An account is given of the physical and chemical properties and characteristics of the sugars and of the composition of the cane, beet and extracted juice. The scope of the work does not admit of a description of the methods of chemical control and analysis adopted in the sugar factory, but the principles which underlie these methods are briefly explained.

Other chapters relate to the special methods of extracting sugar from molasses and the collection and utilisation of the by-products of the industry, including bagasse (or megass), beet-pulp, filter-press cake (with the cane-wax) and the final molasses. Reference is also made to treacle and other by-products of the refinery.

The work is well and clearly written, and, although rather condensed in parts, constitutes a useful text-book for students of sugar manufacture.

MARGARINE. By William Clayton, M.Sc. Pp. xi + 187, with illustrations, Demy 8vo. (London: Longmans, Green & Co., 1920.) Price 14*s*. net.

This work gives a clear and well-illustrated account of the manufacture of margarine by modern processes. The raw materials are described, together with methods for their analysis. The preparation and utilisation of edible hydrogenated oils are discussed, and special chapters are devoted to butter, renovated butter and lard compound. The analysis of butter and margarine is fully dealt with, and reference is made to the causes of the deterioration of butter and margarine during storage. In the final chapter, which is devoted to the subject of "nutritional chemistry," recent investigations on vitamines are dealt with, particularly as they affect butter and its substitutes.

Numerous references are made throughout the text to the original literature and to patent specifications, and a full bibliography is given as an appendix. The work is especially valuable as being the only monograph on margarine which has yet appeared, and it will doubtless meet with a ready welcome from margarine manufacturers and chemists.

A PRACTICAL GUIDE TO COCONUT PLANTING. By R. W. Munro and L. C. Brown. Second edition, with appendix by editor of *Tropical Life*. Pp. xx + 203, Crown 8vo. (London: John Bale, Sons & Danielsson, Ltd., 1920.) Price 15*s*. net.

This is a second impression of a well-known and excellent book, originally published in 1916 (cf. this BULLETIN, 1916, **14**, 646), to which has been added an appendix occupying 17 pages, dealing with the King or dwarf coconut. Handover's article on this subject, which appeared in *The Agricultural Bulletin of the Federated Malay States* for September—October 1919, is reprinted, and the editor of *Tropical Life* adds some useful comments, including a discussion on the yields from the dwarf palms and the possibility of having to modify the machinery employed in dealing with the smaller nuts that they produce. Three excellent photographs of the dwarf coconut have been added, as well as a series of 14 photographs "illustrating the life and work in progress on various estates," but apart from this description they are without numbers or legends, and the reader is left to guess what they are intended to represent—a difficult task in some cases.

The main body of the book is unchanged from the first edition, but on account of the sound practical advice given it will continue to be of value, particularly to those interested in coconut planting in Malaya, Sumatra and Borneo, the information provided having special reference to the conditions obtaining in those countries.

INSECT PESTS AND FUNGUS DISEASES OF FRUITS AND HOPS.—A Complete Manual for Growers. By Percival J. Fryer, F.I.C., F.C.S. Pp. xv + 728, Demy 8vo. (Cambridge: University Press, 1920.) Price 45*s*. net.

The object of this work, as indicated by the sub-title, is to provide the practical grower of fruits and hops with a complete treatise on the insect pests and fungus diseases of these plants. The author attempts to give, not only an account of these pests and diseases, their effect on the plant and their treatment, but, what is so often lacking in books on this subject, adequate means of identifying them, so that the proper measures may be taken by the grower to combat them successfully. In all these directions Mr. Fryer has attained his object. A feature of the book is the abundance of illustrations, including many coloured plates.

The book opens with a short introduction on the general aspect of the subject, followed by a brief section on the structure of plants. Part I deals with insect pests, includ-

ing under this term eelworms, snails and slugs. The chief characteristics of insects are first described, and then the various pests, arranged in groups, such as caterpillars, beetles, sawflies, aphides, etc., are described in detail. The information relating to each pest is divided up under a number of headings, such as description of larva, pupa, adult and eggs, distribution, life-history, trees attacked, frequency of pest, nature of attack, degree of damage, natural enemies, remedies, etc. At the end of each description is placed a diagram representing the different periods of the year in which the insect is in its different stages and pointing out the best time to apply the various remedies. A full description of different insecticides is given and a short account of beneficial insects.

Part II of the book deals with fungus diseases of fruit and their control. There is a short introduction on the general characteristics of fungi, the diseases they cause and preventive measures to be employed. This is succeeded by sections dealing in detail with the diseases affecting each kind of fruit, numerous headings being here also inserted for convenience of reference, and at the end of each description is a diagram showing the time of year the disease is best treated. The final section of this Part deals with fungicides.

Part III deals with spraying and contains descriptions of spraying appliances and methods and a calendar for general spraying work.

Popular Oil Geology. By Victor Ziegler. Second edition. Pp. 171, Crown 8vo. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1920.) Price 15s. net.

This is the second edition of a well-known American work, which first appeared in 1918. The chapter on the laws of migration and accumulation of oil and gas has been rewritten and brought up to date, although perhaps it would have simplified matters if the migration of oil had been subdivided into local and regional. The most valuable and interesting part of the book is that dealing with oil structures. It is well illustrated by American examples, but the diaper structures of Mrazec, of which no examples have hitherto been discovered in the United States, are not explained. The Moreni oil-field of Rumania is the best-known example of this type of structure, which may be briefly described as a pseudo-asymmetrical structure produced by a sedimentary rock, which has protruded through a younger formation.

The chapter on oil shales and their utilisation has also

been rewritten and added to, as increasing attention is being drawn to them in the United States and other countries. The description of the anticlinal axis on page 56 "as the highest part of the anticline or its crest" is hardly correct, for, although the axis does mark the crest of the anticline, it is that along which the anticlinal fold has taken place; it may be vertical or inclined, and therefore, like the folded strata, possesses both strike and dip. In the same way the axis of the syncline is not "the bottom of the trough," but marks the latter, and may also be vertical or inclined. On page 24 maltha is given as synonymous with *chapopote.* According to Pliny, maltha was the name given to an inflammable mud resembling naphtha. It is now applied to mineral tar, and is the *brea* of the Spanish. The Indian term *chapopote* has a wider application. It is the name given to tar seepages or mineral tar, to asphaltum, and, by extension, to petroleum proper; a place where mineral tar, asphaltum or oil seepages occur being known as a *chapopotera.* The index is somewhat inadequate, and in future editions it might well be enlarged.

This little work can be recommended to practical oilmen, and to students it will form a useful introduction to larger works on oil geology and mining.

BOOKS RECEIVED

MANUAL OF TROPICAL AND SUBTROPICAL FRUITS, excluding the Banana, Coconut, Pineapple, Citrus Fruits, Olive and Fig. By Wilson Popenoe. Pp. xv + 474, Demy 8vo. (New York: The Macmillan Company; London: Macmillan & Co., Ltd., 1920.) Price 30*s.* net.

POLITICAL AND COMMERCIAL GEOLOGY AND THE WORLD'S MINERAL RESOURCES. A Series of Studies by Specialists. Edited by J. E. Spurr. Pp. ix + 562, Med. 8vo. (New York and London: McGraw-Hill Book Company, Inc., 1920.) Price 30*s.* net.

MINERALOGY: AN INTRODUCTION TO THE STUDY OF MINERALS AND CRYSTALS. By E. H. Kraus, Ph.D., Sc.D., and W. F. Hunt, Ph.D. Pp. xiv + 561, Med. 8vo. (New York and London: McGraw-Hill Book Company, Inc., 1920.) Price 27*s.* net.

AN INTRODUCTION TO THE CHEMISTRY OF PLANT PRODUCTS. Vol. I. On the Nature and Significance of the Commoner Organic Compounds of Plants. By Paul Haas, D.Sc., Ph.D., and T. G. Hill, A.R.C.S., F.L.S. 3rd ed. Pp. xiii + 414, Med. 8vo. (London: Longmans, Green & Co., 1921.) Price 16*s.* net.

REPORTS OF RECENT INVESTIGATIONS AT THE IMPERIAL INSTITUTE

The following summaries have been prepared from a selection of the Reports made by the Director of the Imperial Institute to the Dominion, Colonial and Indian Governments.

COTTON GROWING IN RHODESIA

THE cultivation of cotton in Rhodesia is at present in an experimental stage. It has been shown that areas suitable for cotton growing exist in Northern Rhodesia, particularly in the Zambesi valley (cf. this BULLETIN, 1918, **16**, 579). The Agricultural Department has recently reported favourably on certain localities in the districts of Mangwende, Mazoe and Lomagundi in Southern Rhodesia, all watered by the Zambesi or its affluents. In 1919 ninety-one farmers undertook trials in twelve regions. In all 1,000 acres were planted, so that fair conclusions might be reached as to the possibility of the crop, and the Director of Agriculture, in his *Report* for 1919, states that there is every reason to anticipate a good measure of success. It was expected that, in 1920, 1,200 acres would be planted with cotton. With a view to assisting the development of the industry the British Cotton Growing Association have offered prizes to be competed for in the autumn of 1920 and the spring of 1921, and it is hoped that by this means a thorough trial of the crop will be ensured.

Eight samples of seed-cotton grown on the Government Experiment Farm at Gwebi, and by farmers in different parts of Southern Rhodesia, have been examined recently at the Imperial Institute. The soil of Gwebi is a red diorite, that at Darwendale, Arcturus and on the Ruia Estates Concession is a sandy loam and that at Shamva consists

of black vlei. The results of examination of the samples are given below, arranged under the three varieties of cotton represented. The ginned cotton was valued in Liverpool, in August 1920, when "middling" American was quoted at 23·50*d.* per lb.

"King" Cotton

No. 1. *Grown at Gwebi Experiment Farm.*—This sample yielded 32 per cent. of lint on ginning, or 3·6 grams per 100 seeds. The lint was soft, pale cream-coloured and of fair lustre; it was slightly stained and contained a quantity of immature fibre. The seeds were of moderate size and covered with whitish or pale brown fuzz; a few brown seeds without fuzz were also present.

The cotton was rather soft and weak, and ranged in length from 0·6 to 1·1 in., being mostly from 0·8 to 0·9 in. The diameter varied from 0·0006 to 0·0012 in., with an average of 0·0008 in.

The cotton was valued nominally at 20*d.* per lb.

No. 2. *Grown at Darwendale.*—The yield of lint in this case was 38 per cent., or 5·3 grams per 100 seeds. The lint was fairly soft, cream-coloured and of fair lustre; it was more mature than sample No. 1. The seeds were similar to those of sample No. 1, but bore fuzz of slightly darker colour.

The cotton was of good strength, and varied from 0·7 to 1·1 in. in length, being mostly 0·9 to 1·1 in., with an average of 1·0 in. The diameter ranged from 0·0007 to 0·0011 in., with an average of 0·00093 in.

The cotton was valued nominally at 28·5*d.* per lb.

No. 3. *Grown at Alderley, Arcturus.*—This yielded 36 per cent. of lint, or 4·9 grams per 100 seeds. The lint was fairly soft, pale cream-coloured and of fair lustre; it was somewhat stained and contained a fair quantity of immature fibre. The seeds were similar to those of sample No. 2.

The cotton was of fairly good strength, and ranged in length from 0·8 to 1·1 in., being mostly from 0·8 to 1·0 in., with an average of 0·9 in. The fibres varied in diameter from 0·0006 to 0·0010 in., with an average of 0·00079 in.

The cotton was valued nominally at 22*d.* per lb.

"BANCROFT" COTTON

No. 4. *Grown at Darwendale.*—This yielded 26 per cent. of lint, the yield per 100 seeds being 4·2 grams. The lint was soft, pale cream-coloured and lustrous; it contained a small amount of immature fibre. The seeds were very large, and thickly covered with white or pale brown fuzz, a few seeds devoid of fuzz also being present.

The strength of this cotton was slightly uneven, but mostly good. The length varied from 0·9 to 1·3 in.; being mostly from 1·0 to 1·2 in., with an average of 1·1 in. The diameter ranged from 0·0006 in. to 0·0010 in., with an average of 0·00082 in.

The cotton was valued nominally at 31·50*d.* per lb.

No. 5. *Grown at Alderley, Arcturus.*—This yielded 31 per cent. of lint on ginning, the yield per 100 seeds being 4·8 grams. The lint was similar to that of sample No. 1, but was less stained. The seeds were slightly smaller than those of sample No. 4, and bore fuzz of a darker colour but otherwise very similar.

The strength of the cotton was fairly good, and the length varied from 0·7 to 1·1 in., being mostly from 0·8 to 1·0 in., with an average of 0·9 in. The diameter ranged from 0·0006 to 0·0012 in., with an average of 0·00082 in.

The cotton was valued nominally at 30*d.* per lb.

No. 6. *Grown at the Gwebi Experiment Farm.*—This sample gave a yield of 29 per cent. of lint on ginning, or 4·8 grams per 100 seeds. The lint was soft, pale cream-coloured and lustrous. It was slightly stained and contained a small amount of immature fibre. The seeds were similar to those of sample No. 5.

The cotton was of fairly good strength, and varied in length from 0·7 to 1·3 in., being mostly from 0·9 to 1·2 in., with an average of 1·1 in. The fibres had a diameter ranging from 0·0006 to 0·0010 in., with an average of 0·00074 in.

The cotton was valued nominally at 33·50*d.* per lb.

No. 7. *Grown at Shamva.*—The yield of lint on ginning was 30 per cent., or 4·0 grams per 100 seeds. The lint was soft, pale cream-coloured, and of fair lustre; it was slightly stained and contained a fair quantity of im-

mature fibre. The seeds were similar to those of sample No. 4, but were slightly smaller.

The strength of the cotton was very uneven, and generally rather weak and soft. The length ranged from 0·9 in. to 1·2 in., being mostly from 1·0 to 1·2 in., with an average of 1·1 in. The diameter varied from 0·0006 to 0·0013 in., with an average of 0·00089 in.

The cotton was valued nominally at 20*d.* per lb.

"Nyasaland" Cotton

No. 8. *Grown on the Ruia Estates Concession.*—This sample gave a yield of 32 per cent. of lint on ginning, the yield per 100 seeds being 4·9 grams. The lint was soft, pale cream-coloured and of good lustre, but was rather badly stained and contained a fair amount of immature fibre. The seeds were rather large, and covered with brown fuzz. A large proportion of the seeds were immature and badly affected by disease.

The cotton was of fairly good strength, and varied in length from 0·8 to 1·2 in., being mostly from 1·0 to 1·2 in. with an average of 1·1 in. The diameter ranged from 0·0006 to 0·0010 in., with an average of 0·00075 in.

The cotton was valued nominally at 28*d.* per lb.

General Remarks

Lint.—From the results given in the foregoing pages, it will be seen that most of the samples contained a quantity of immature fibre, which impairs the value of the cotton for both spinning and dyeing, but they all represent cottons which would be readily saleable in the United Kingdom for textile purposes. The cottons were very similar in length and strength to ordinary American Upland types, although inferior to some of the improved varieties of American cotton. The length of staple is not very high, and is rather variable, but the irregularity could doubtless be overcome in the future by the adoption of a system of seed selection.

Some of the samples were rather stained, owing to insect attack or disease; measures of control should be adopted to prevent such attacks as far as possible. In

preparing the cotton for export the stained material should be kept apart from the clean cotton and baled separately.

Seed.—Representative samples of the seed of the three varieties ("King," "Bancroft" and "Nyasaland") were analysed at the Imperial Institute, and found to contain respectively 14·0, 13·9 and 12·5 per cent. of oil.

Oil-seed crushers in London, to whom samples of the seed were submitted, stated that they were of very low quality as well as being "woolly." They considered that the seed would be worth only about £8 10*s.* per ton in this country in competition with Bombay cotton seed, which was readily obtainable at £11 10*s.* per ton (July, 1920) and contains about 19 per cent. of oil as against only 12·5 to 14 per cent. in these Rhodesian samples. The firm further stated that they would not care to purchase such inferior seed, and it therefore seems doubtful whether such seed could profitably be shipped from Rhodesia to the United Kingdom.

THE CULTIVATION OF BEANS IN BURMA AND ASSAM

THE experimental cultivation of edible beans in Burma, referred to in earlier numbers of this BULLETIN (1914, **12**, 355; 1915, **13**, 196; 1916, **14**, 150; 1918, **16**, 275), is being continued at the Mandalay Agricultural Station and the Natywagon Sub-station, and a large number of samples grown in 1918 have been examined at the Imperial Institute. The beans included in this series comprise different forms of (1) *Phaseolus lunatus*, viz. Madagascar beans, pe-nge (a variety with small white seeds), pe-byugale (white Rangoon beans), and several varieties of coloured Rangoon beans; and (2) *Phaseolus calcaratus.*

I. PHASEOLUS LUNATUS

Madagascar Beans

An account of the cultivation of this variety of bean and a summary of the results of examination of all the earlier samples will be found in this BULLETIN (1918, **16**, 276).

The present samples were stated to have been derived

from seed supplied by the Imperial Institute in 1912, 1913 and 1914, and were as follows:

Sample.	Original seed supplied in	Colour.	Average weight of 100 beans.
			Grams.
No. 1. 7th year's produce from Natywagon (1918)	1912	Fairly good white to creamy white, some beans showing yellow discolorations	102·4
No. 2. 6th year's produce from Natywagon (1918)	1913	Fairly good white with occasional yellow discolorations	94·2
No. 3. 5th year's produce from Natywagon (1918)	1914	Fairly good white with occasional yellow discolorations	97·2
No. 4. 6th year's produce from Mandalay (1918)	1913	Creamy white with occasional yellow discolorations	87·2
No. 5. 5th year's produce from Mandalay (1918)	1914	Creamy white with occasional yellow discolorations [1]	63·2

[1] *About half of this sample consisted of pe-nge beans.*

The beans were all fairly plump and in good condition. They were chemically examined in order to determine the percentages of prussic acid which they yielded, with the following results:

Sample.	Yield of prussic acid from the beans as received.
	Per cent.
No. 1	0·0045
No. 2	0·0045
No. 3	0·003
No. 4	0·0035
No. 5	0·0045

Four of the present samples (Nos. 1, 2, 4 and 5) were inferior in colour to the corresponding samples of the 1916–17 crop (*loc. cit.*, p. 278), whilst the other sample (No. 3) was about equal in colour to the 1916–17 product. The crop for the season 1916–17 reached the highest standard of colour so far obtained in the cultivation experiments, being in some cases equal to the "good white" colour of the original seed beans. The present samples were in all cases of much better colour than the corresponding samples representing the crops of 1914–15 and 1915–16, and on the whole about equal to the 1913–14 crop in this respect.

In samples Nos. 1 to 4 the size of the beans was about the same as in the 1916–17 crop, but No. 5 was a mixture of Madagascar and pe-nge beans, and consequently showed great variation in size.

The yields of prussic acid from the present samples are in general slightly higher than in the case of the 1916–17 crop, but the amounts are still negligible and the beans would be quite harmless.

Madagascar beans represented by the present samples would be readily saleable, but they are slightly inferior both in colour and size to the ordinary quality sold on the United Kingdom market, and would realise somewhat lower prices.

Pe-nge Beans

As already mentioned, the pe-nge bean is a variety of *P. lunatus*, with small white seeds. It was introduced into Burma from the United States in 1914–15. The results of examination of earlier samples are given in this BULLETIN (1918, **16**, 281). Those recently examined were as follows:

Sample.	Colour of beans.	Average weight of 100 beans.
		Grams.
No. 6. 5th year's produce, Natywagon, 1918	Creamy white, similar to 3rd year's crop (1916–17)	40·5
No. 7. 4th year's produce, Mandalay Farm, 1918	Creamy white, slightly inferior to 1st year's crop (1915–16)	38·7
No. 8. 4th year's produce, Mandalay Farm (ordinary), 1918	Good creamy white, similar to 1st year's crop (1915–16)	37·6

It was found that all these samples yielded 0·010 per cent. of prussic acid, expressed on beans containing 10 per cent. of moisture. This yield is higher than that from earlier crops grown at Natywagon and Mandalay, the highest figure previously obtained in this series of trials being 0·0055 per cent. in samples from both places. The present increase to 0·010 per cent., although undesirable, is, however, not sufficient to render the beans harmful.

The present sample No. 6 from Natywagon maintained the good colour of the crop of 1916–17, and showed a slight improvement in size. As in the previous seasons, the beans from Mandalay were slightly superior in colour to

those from Natywagon. In size the present samples from Mandalay were slightly inferior to the Natywagon beans, but rather better than those previously received from Mandalay.

Pe-byu-gale Beans

Two samples of these beans, which represent the white Rangoon beans exported from Burma, were received. Those previously examined are dealt with in this BULLETIN (1914, **12**, 355; 1918, **16**, 283).

The present samples were as follows:

No. 9. "Produce of Natywagon, 1918."

No. 10. "Produce of Mandalay Farm, 1918."

The beans were similar to the previous samples of pe-byu-gale beans from Burma, and were plump, of good appearance, and in sound condition. Of the two samples, No. 10 was slightly superior in appearance.

The yields of prussic acid, expressed on beans containing 10 per cent. of moisture, were as follows:

Sample.	Yield of prussic acid. *Per cent.*
No. 9	0·007
No. 10	0·008

These beans yielded less prussic acid than two samples of pe-byu-gale beans examined in 1918 (*loc. cit.*, 1918, **16**, 283), the figures for the latter being 0·016 and 0·018 per cent. These percentages represent harmless amounts of prussic acid, and the even lower yield obtained from the present samples is a very satisfactory feature.

Cultivation of Pe-byu-gale Beans in Assam.—In comparison with the pe-byu-gale beans from Burma, reference may be made here to the results of examination of beans of the same variety forwarded from Assam in 1919. The latter were grown from Burma seed at the Jorhat Government Farm, where the climate is similar to that of Burma, the rainfall being 90 in. The yield of seed was stated to be 925 lb. per acre.

The beans were cream-coloured, and of moderately good appearance. Many of them showed occasional yellow patches, and a small proportion of shrivelled, dis-

coloured beans was present, together with a few coloured Rangoon beans.

The percentage of prussic acid yielded by this sample was 0·018 per cent., as compared with a range of from 0·007 to 0·03 per cent. in the case of five samples of pe-byu-gale beans from Burma.

These pe-byu-gale beans from Assam were similar in size and general character to the samples of the same variety received from Burma, but were somewhat inferior in appearance owing to the presence of some discoloured and shrivelled beans. The amount of prussic acid yielded by the sample compares satisfactorily with that given by the earlier samples of the beans grown in Burma, but is higher than in the case of the two later samples dealt with above.

Coloured Rangoon Beans

Four samples from Burma, representing three varieties of coloured *P. lunatus* beans, were included in the series recently examined. Coloured beans previously investigated at the Imperial Institute are dealt with in this BULLETIN (1914, **12**, 355 ; 1915, **13**, 196).

No. 11. "*Bo-sa-pe (Lashio, Northern Shan States).*"—This consisted of reddish-brown or pinkish-brown beans, with strong white markings radiating from the hilum. The beans were 0·5 to 0·7 in. long, and were flat, rather thin, and of rounded oblong shape, tapering at one end. The seed coat was thin and close-fitting, and the interior of the beans was cream-coloured. The sample was in sound condition, but slightly dusty.

No. 12. "*Pe-leik-pya.*"—These beans were similar in shape and size to those of sample No. 11 (bo-sa-pe). They were of a dark brownish- or blackish-purple colour, with strong white markings radiating from the hilum. The beans were clean and in sound condition.

No. 13. "*Pe-gya R/b,*" *Mandalay Farm*, 1918.

No. 14. "*Pe-gya R/d,*" *Mandalay Farm*, 1918.

These samples consisted of beans of brownish-red to pinkish-purple colour with inconspicuous yellow specks in many cases, and similar in appearance to the Rangoon red beans of commerce. The beans were clean and in sound condition.

The results of chemical examination of the four samples are shown in the following table :

	No. 11. Per cent.	No. 12. Per cent.	No. 13. Per cent.	No. 14. Per cent.
Moisture	10·3	10·2	9·9	9·8
Crude proteins	21·9	20·6	22·2	20·2
Fat	0·9	1·2	0·8	1·7
Carbohydrates (by difference)	59·2	58·8	58·3	59·3
Fibre	4·6	5·2	5·1	5·2
Ash	3·1	4·0	3·7	3·8
Nutrient ratio	1 : 2·8	1 : 3·0	1 : 2·7	1 : 3·1
Food units	116	113	116	114
Yield of prussic acid, *per cent.*	0·050	0·045	0·050	0·050

It will be seen that the beans contained a high percentage of protein and had a good feeding value, but they yielded a considerable amount of prussic acid, and in the raw state might be dangerous to live-stock. Samples Nos. 13 and 14 yielded a higher percentage of prussic acid than previous samples of pe-gya beans examined at the Imperial Institute, the highest figure hitherto observed having been 0·04 per cent. (*loc. cit.*, 1914, **12**, 358). In appearance and colour, samples Nos. 11 and 12 were inferior to Rangoon red beans, which they resembled in composition. Nos. 13 and 14 were similar to the ordinary Rangoon red beans of commerce, and were of good appearance.

II. Phaseolus calcaratus

The seed of this plant, which is widely cultivated in India, is commonly known there as the "rice" bean. It is also grown to some extent in the Far East (cf. this Bulletin, 1917, **15**, 520). Five different forms grown at the Mandalay Farm in 1918 have been examined.

No. 15. "*Bi-nark* (*black*)."—This sample consisted of small black beans with a large and prominent white hilum. The beans were rectangular in shape, and from 0·2 to 0·3 in. long. They had a thin, closely fitting seed coat, and the cotyledons were of cream or greenish-cream tint. The sample had suffered from a slight insect attack, but the beans were plump and otherwise in good condition.

*No.*16. "*Bu-hlule* (*red*)."—Dark purplish-brown beans, similar in shape to those of sample No. 15, but slightly

longer, ranging from 0·25 to 0·4 in. They had a similar prominent hilum. The sample had suffered somewhat from insect attack.

No. 17. "*San-to-hai* (*speckled*)."—Dull brownish-yellow beans, marbled with black, similar in shape and in appearance of the hilum to those of sample No. 15, but larger than the latter, being 0·3 to 0·4 in. in length. The sample had suffered from insect attack and was in a rather dusty condition.

No. 18. "*Pe-yin* (*common yellow*)."—Light greenish-yellow to brownish-yellow beans similar in shape and in the appearance of the hilum to those of sample No. 15, but smaller, being only 0·2 to 0·25 in. in length. The sample had been slightly attacked by insects, but the beans were otherwise clean and in sound condition.

No. 19. "*Kachin-pe* (*Bhamo*)."—Greenish-yellow or brownish-yellow beans, a few being marbled with black. In shape and appearance of the hilum the beans resembled those of samples Nos. 15 to 18. The beans measured from 0·2 to 0·35 in. in length. Some shrivelled beans were present, but otherwise the sample was sound and clean, and showed no signs of insect attack.

The beans were submitted to chemical examination, with the results given in the following table :

	No. 15. *Per cent.*	No. 16. *Per cent.*	No. 17. *Per cent.*	No. 18. *Per cent.*	No. 19. *Per cent.*
Moisture	9·0	9·3	10·6	10·3	10·3
Crude proteins . . .	21·5	21·4	23·0	25·3	20·8
Fat	0·5	0·6	1·0	0·6	0·5
Carbohydrates (by difference)	60·3	59·4	55·4	54·7	59·6
Fibre	4·9	5·2	5·4	5·2	4·8
Ash	3·8	4·1	4·6	3·9	4·0
Nutrient ratio . . .	1 : 2·9	1 : 2·8	1 . 2·5	1 : 2·2	1 : 2·9
Food units. . . .	115	114	115	119	113

None of the samples yielded prussic acid.

These beans contained a high percentage of protein, and would have a good feeding value. The dark colour and large hilum of Nos. 15 and 16 are, however, unattractive features. In composition the beans are similar to black gram (*Phaseolus Mungo*) and cow-peas (*Vigna Catjang*), and they would all be readily saleable as feeding stuffs in the United Kingdom. The most promising of the five

samples was No. 18, which contained the highest percentage of protein and was of good colour; it resembled black gram in appearance, but had a more prominent hilum.

FEEDING VALUE OF THE PODS AND SEEDS OF *PROSOPIS STEPHANIANA*

THE genus *Prosopis* comprises some thirty species of leguminous trees or shrubs, occurring in tropical and subtropical countries. The best known species is *P. juliflora*, the mesquit or algaroba tree of the West Indies and other parts of tropical America, which has been introduced into most of the warmer regions of the Old World. The pods of this tree, like those of the carob, are rich in sugar and form a valuable feeding stuff for live-stock. They are also used as food, in the form of flour, by the natives of Mexico. The pods of other species, e.g. *P. glandulosa*, *P. pubescens*, *P. horrida*, *P. alba* and *P. spicigera*, are also suitable for use as feeding stuffs, whilst those of *P. dulcis* are rich in tannin.

Another species, *P. Stephaniana*, a shrub or bushy tree, is indigenous to Cyprus, and occurs also in the Punjab, Afghanistan and the Caucasus. Pods and seeds of this plant were forwarded to the Imperial Institute from Cyprus with a view to ascertaining their value as feeding stuffs.

The pods were dark reddish-brown in colour and of irregular shape, measuring from ¾ to 1¾ in. in length and from ½ to 1 in. in breadth. Each pod contained several small, flat, oval, brown seeds with tough skins and pale yellow cotyledons.

The pods and seeds were analysed at the Imperial Institute with the following results:

	Whole pods. *Per cent.*	Pod cases only. *Per cent.*	Seeds only. *Per cent.*
Moisture	10·1	10·4	6·5
Crude proteins	13·0	10·4	18·2
Fat	2·6	2·5	2·8
Carbohydrates (by difference)	56·8	56·2	58·0
Fibre	14·1	17·0	8·4
Ash	3·4	3·5	3·1
Nutrient ratio	1 : 4·8	1 : 6·0	1 : 3·5
Food units	96	89	111

No alkaloids or cyanogenetic glucosides were detected in the samples.

The pods (freed from seeds) contained 3·8 per cent. of sugar (calculated as dextrose), so that they differ materially in this respect from carob pods, which contain from 30 to 50 per cent. of sugar. No tannin was present in the pods.

The results of the examination show that these Prosopis pods and seeds contain a fairly high percentage of proteins, and that no alkaloids or cyanogenetic glucosides are present. Their value as feeding stuffs is, however, reduced by the highly fibrous nature of the pods and the hardness of the seed coat. The pods of the allied species *P. juliflora*, which contain a larger percentage of sugar (25 to 28 per cent.), are stated to be used as a feeding stuff, and trials might therefore be made with the *P. Stephaniana* pods and seeds.

THE COMMERCIAL UTILISATION OF PERILLA SEED

In view of the increasing demand for drying oils during recent years, it has been thought that the cultivation of Perilla seed (*Perilla ocymoides*) might be advantageously encouraged in British possessions. The oil obtained from these seeds is a valuable drying oil (see this BULLETIN, 1912, **10**, 303), and there is no doubt that supplies of the seed or the oil would meet with a ready sale in the United Kingdom. At present Perilla seed is grown for commercial purposes principally in Manchuria, China and Japan (*loc. cit.*, 1917, **15**, 583). In Japan the seeds are sown in April to May in rows 2 ft. apart, and when the plants are an inch or so high they are thinned out to a distance of 3–4 in. The plants attain a height of about 5 ft. in September, when they bear small white flowers, and the seeds ripen about the end of October. Five to six lb. of seed are required to sow an acre, and the yield is said to be from 1,000 to 1,500 lb. per acre, depending on the character of the soil. The plants are said to grow well in a sandy loam.

A supply of Perilla seed was obtained by the Imperial Institute from Japan, and samples of from 2 to 3 lb. each were forwarded in 1918 to India, East Africa, South

Africa, Rhodesia and Cyprus for trial cultivation. A report on the experiments in Cyprus, and a sample of seed produced there have now been received, and are dealt with in the following pages.

The first sowing was made in November 23, 1918, at the Experimental Garden, Nicosia, but this was a failure, owing to floods, and a further sowing was made on February 14, 1919. The seed was sown by means of a hand-drill in rows 2 ft. apart, and germination commenced in fourteen days. On April 30 and May 1, when the plants were 3–4 in. high, they were thinned out, and left at intervals of 4 in. in the rows. The plants were watered periodically during their growth and were hoed when young. The soil was dressed with a chemical manure containing 6 per cent. of nitrogen, 8 per cent. of phosphoric acid and 8 per cent. of potash, at the rate of 98 lb. per plot of approximately 10 rods. The seeds were gathered on October 20, 1919, when most of the plants were dry. The yield of seed was 28 lb., equivalent to about 450 lb. per acre, which is much lower than that usually obtained in Japan. This low yield is attributed partly to the plants growing too vigorously, thus becoming over-crowded, and partly to the effect of a hot wind which dried up the plants just when they were in full bloom.

The seeds received for examination were of pale brown colour, and in good condition. They contained 6·3 per cent. of moisture and yielded 43·1 per cent. of oil, equivalent to a yield of 46·0 per cent. of oil from the dry seed. The oil was examined with the following results :

	Present sample of oil.	Figures recorded for Perilla oil.
Specific gravity at 15°/15° C.	0·9298	0·9318 to 0·9372
Refractive index $n_{D_{40}}$	1·472	1·475
Saponification value	190·5	189·6 to 193·8
Iodine value . . . *per cent.*	185·0	185·6 to 206·1

It will be seen from the above results that the constants of this oil correspond closely with those previously recorded for Perilla oil.

The residue left after extraction of the oil from the seed consisted of a fine greyish-white meal, with a very slight but pleasant taste. The results of its chemical examination are shown in the following table in comparison

with the figures recorded for undecorticated cotton-seed cake.

	As analysed.	Perilla meal calculated to contain 7 per cent. of fat.	Undecorticated cotton-seed cake.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	9·6	9·0	13·75
Crude proteins	38·1	35·6	24·62
Fat	0·5	7·0	6·56
Carbohydrates (by difference)	20·8	19·4	29·28
Fibre	20·2	18·9	21·19
Ash	10·8	10·1	4·60
Nutrient ratio	1:0·6	1:1·0	1:1·67
Food units	117	126	107

The amount of fibre in the Perilla-seed meal is thus slightly below that in undecorticated cotton-seed cake, whilst the percentage of proteins is considerably higher.

The results of this examination show that the present sample of Perilla seed was of excellent quality and furnished a good yield of oil possessing the usual properties of Perilla-seed oil. The oil would find a market for paint and varnish making and for other purposes for which a "drying" oil is required.

The residual meal contained a large amount of protein, and its composition indicated that it would be a valuable feeding stuff notwithstanding the high percentage of fibre present. No information is, however, available at the Imperial Institute as to the value of Perilla cake or meal as a feeding stuff, and trials would therefore be required in order to determine this point.

Either the seed or the oil would be readily saleable in the United Kingdom at good prices, the actual value depending on the current prices of linseed and linseed oil. It was pointed out to the authorities in Cyprus that it would be desirable to continue the experiments in the island, and that if commercial quantities of seed become available at a later date the Imperial Institute would be glad to make arrangements for the sale of a trial consignment.

THE OIL OF SOUTH AFRICAN MAROOLA NUTS

THE maroola nut is the product of *Sclerocarya Caffra*, Sond., a small tree, 20–30 ft. in height, belonging to the natural order Anacardiaceæ. The tree is found only in Natal and the Transvaal, being very plentiful in the Bush

Veld and the Low Veld. The fruit is a drupe, and when ripe is about the size of a small hen's-egg, and of a yellow or greenish-yellow colour. The thin pulp which surrounds the nut has a flavour similar to that of the mango, but is much more acid. An intoxicating drink is prepared from the fruits by the natives of Amatongaland. It is said that Low Veld cattle are particularly fond of feeding on the ripe fruits as they fall from the trees, and that milk from cows fed on them is exceptionally rich in cream.

About 1¼ cwts. of the nuts, collected in the Pretoria District, were recently forwarded to the Imperial Institute in order to ascertain whether they would be of commercial value.

The nuts were of irregular shape, averaging 5 grams in weight and containing from 1 to 3 kernels. The shell, which was very tough and fibrous, was covered with a thin layer of dried pulp of a pinkish-brown tint. The nuts consisted on the average of 90 per cent. shell, and only 10 per cent. kernel.

Experiments in the cracking of the nuts were made at the Imperial Institute with two kinds of nut-cracking machine. In one case the kernels were broken in the process, so that it was difficult to separate them from the shells, and in the second case the shells were not all properly broken, and it would not be practicable to extract the kernels by means of this machine. In order to obtain a sample of the kernels for examination the nuts had to be cracked by hand.

The kernels contained 5 per cent. of moisture and yielded 56·2 per cent. of oil, equivalent to a yield of 59·2 per cent. from the dry kernels. The oil, which was clear, limpid, and pale yellowish-brown in colour, was examined with the following results, in comparison with corresponding figures recorded for a sample of maroola oil from the Northern Transvaal:

	Present sample.	Results previously recorded.
Specific gravity at 15° C.	0·9167	0·9153
Refractive index n_{D40}	1·460	—
Melting point of fatty acids	25·0° C.	24·3° C.
Acid value	3·7	3·2
Saponification value	193·5	—
Iodine value . . . . *per cent.*	76·6	72·9
Soluble volatile acids	0·1	—
Insoluble volatile acids	0·45	—
Unsaponifiable matter . . *per cent.*	0·6	0·93

The kernels of these maroola nuts give a good yield of oil of the "non-drying" type, which would be suitable for soap manufacture and possibly for edible use. In view, however, of the difficulty of cracking the nuts and separating the kernels, it is very unlikely that the nuts could profitably be used as a source of oil.

CEARA RUBBER FROM THE SUDAN

THE Ceara rubber tree (*Manihot Glaziovii*) has been grown experimentally by the Forests Department at Kegulu in the Sudan for some years. Four samples of rubber produced there have been examined recently at the Imperial Institute.

No. 1. "*Light.*"—This sample consisted of pieces of light brown, diamond sheet rubber which was opaque and rather soft, but on the whole of good strength.

No. 2. "*Medium.*"—Similar to No. 1 except that the colour was darker.

No. 3. "*Dark.*"—This consisted of two pieces of weak, rather soft, dark brown, diamond sheet.

No. 4. "*Scrap.*"—This consisted of irregular pieces of medium to dark brown scrap rubber, of good but rather variable appearance. Traces of mould were present and slight "tackiness" was observed. On washing, the rubber was found to contain a good deal of bark and other impurities, and it did not cohere well.

The rubber was analysed at the Imperial Institute with the following results, which are shown in comparison with corresponding figures for a previous sample of Ceara sheet rubber from Kegulu examined in 1911 (see this BULLETIN, 1912, **10**, 552):

	No. 1. "Light."	No. 2. "Medium."	No. 3. "Dark."	No. 4. "Scrap."	Previous sample of Ceara Sheet.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Loss on washing	2·6	3·6	1·7	6·2	—
The dry washed rubber contained:					
Caoutchouc	90·8	92·1	89·3	83·7	84·2
Resin	3·9	3·8	4·1	4·1	6·5
Proteins	4·0	2·9	5·0	6·9	7·9
Ash	1·3	1·2	1·6	5·3	1·4

These results show that the rubber was of satisfactory composition, the three samples of sheet rubber being superior to the previous sample from Kegulu in containing less resin and proteins. Nos. 1 and 2 possessed satisfactory physical properties, being about equal in strength, but No. 3 was of poorer quality and somewhat soft and weak. No. 4 was a fairly good specimen of scrap rubber.

Nos. 1 and 2 were each regarded as worth about 1*s.* to 1*s.* 1*d.* per lb. in the United Kingdom at the time of report (November, 1920), when ribbed smoked Para sheet was quoted at 1*s.* 1½*d.* to 1*s.* 2½*d.* per lb., whilst it was considered that No. 3 would realise a slightly lower price. The scrap rubber represented by No. 4 was probably worth about 9*d.* to 10*d.* per lb., but might be difficult to dispose of under the conditions then prevailing.

In general, the results of the investigation of these samples showed that this Ceara rubber from Kegulu was of good marketable quality.

VEGETABLE AND MINERAL SOURCES OF ALKALI SALTS IN NIGERIA

SAMPLES of various saline materials were collected in the course of the Mineral Survey of Northern Nigeria, conducted in connection with the Imperial Institute, and the results of their examination were given in the *Reports* of the Survey for 1904–5 and 1906–7 (Cd. 2875, 1906, pp. 4, 10, 12, 20; Cd. 3914, 1908, pp. 2–14). A further series of samples, most of which came from the Bornu Province, have now been examined, and the results are given in the following pages. The samples were as follows:

Salts of Vegetable Origin

No. 1. "*Manda Kighr.*"—This consisted of one sandy-coloured cone weighing 15 lb., which was stated to have been sold at Mongonu for 1*s.* 6*d.* It had been prepared from the ash obtained by burning the branches of the "kighr" or "kegu" tree. The botanical identity of this tree is not known with certainty, but it is believed to be *Salvadora persica.*

No. 2. " *Manda Kighr.*"—This second sample was stated to have been made in French territory, and to have been sold at Mongonu at 4*s.* per cone of 34 lb. The sample received for examination consisted of two cones, of a creamy-white colour, weighing 20 and 34 lb. respectively.

No. 3. " *Kegu or Kighr salt* (*Manda Kighr*)."—This was stated to have been prepared in the Chad district of Bornu Province by lixiviating the ash of the " kighr " tree with water, and slowly evaporating the solution to dryness. The price of the salt at Geidam was quoted as 3*s.* per cone of 40 lb. The material received consisted of one cone of white crystalline salt weighing 40 lb.

No. 4. " *Alfadara* (*also known as Labatera*)."—This salt was stated to have been made at Kabi in French territory, and sold at Geidam for 1*s.* per cone. The sample received consisted of two cones of brownish-white crystalline material weighing in all 38 lb.

No. 5. " *Manda Karia.*"—This salt was made at Ngornu and Ngelewa, from the ash obtained by burning three grasses growing near Lake Chad. It was regarded as being inferior to " kighr " salt, and the price at Mongonu per cone of 19 lb. was 1*s.* 6*d.* Two cones of this salt, of good white colour, weighing 37 and 19 lb. respectively, were received for examination.

No. 6. " *Manda Karia.*"—This sample consisted of one cone of salt of good white colour, weighing about 26 lb. The cone was stated to have been sold at Mongonu for 2*s.* 6*d.*

Salts of Mineral Origin

No. 7. " *Sheri salt* (*Manda Sheri*)."—This salt was stated to have been made in French territory, and was sold at 2*s.* per cone of 16 lb. at Maiduguri. It was prepared by scraping up the saline incrustation, left after the pools at the saltings have dried up, extracting the material with water, and evaporating the liquid to dryness over a grass fire. The material received for examination consisted of two cones weighing 16 and 19 lb. respectively, and having a creamy-white colour.

No. 8. " *Allaussi salt.*"—This was stated to have

been made from the liquid in the pools whence the Sheri salt (No. 7) is obtained. When this liquid has been concentrated by solar heat, it is further evaporated in small pots over a fire until it will set to a solid mass on cooling. The material received for examination, which consisted of two cones weighing 13 and 14 lb. respectively, was of greyish-white colour.

No. 9. "*Mongul salt* (*Manda Mongul*)."—This salt was stated to have been made in the Manga district, and to have been sold in Geidam at 3*d.* per cone of 11 lb. Two cones, each weighing about 11 lb., were received for examination. The salt, which was of brown colour, was contaminated with a considerable quantity of insoluble mineral matter.

No. 10. "*Bilma salt* (*Manda Yergal*)."—This salt was collected at Bilma in French territory, and was sold at Geidam at about 6*s.* for 30 lb. The rain water from the land on a higher level than the Bilma deposits percolates through the saltings and collects as a pool. When this evaporates a thick deposit of salt remains, which is scraped up into heaps and allowed to dry. The material received for examination consisted of about 29 lb. of a cream-coloured crystalline mass.

No. 11. "*Pieski salt* (*Manda pieski*)."—This salt is made in the Manga district of Bornu province by the lixiviation of salt-impregnated earth. Its price at Geidam was stated to be about 6*d.* per slab of 11 lb. The specimen received for examination comprised two slabs, each weighing 11 lb., and consisting of a greyish crystalline mass.

No. 12. "*Ngal, or Gangorosa.*"—This salt was obtained from a pool in the Manga district, and its price at Geidam was stated to have been 3*d.* per cone of 12 lb. It is collected from the deposit which forms as the pool dries up. It is stated to be employed for preparing skins. One cone, weighing 12 lb., and consisting of a dirty-white crystalline material, was received for examination.

No. 13. "*Red Potash* (*Jan Kanwa*)."—This salt, which is also collected in the Manga district, is stated to be prepared at the saltings by scraping the efflorescent salts from the surface of the ground after the water has

dried up. The price of this material at Geidam was stated to be about *6d.* for 25 lb. The sample received for examination, which weighed about 12 lb., consisted of a reddish crystalline mass.

No. 14. "*White Potash* (*Ferren Kanwa*)."—This salt, collected in the Manga district, was stated to have been prepared in a similar manner to sample No. 13, but at a later period of the year, when the saltings were dry. The salt was stated to have been sold at Geidam at *6d.* per 25 lb. The sample received for examination consisted of about 12 lb. of a dirty-white crystalline mass.

No. 15. "*Chad Natron* (*Kilbu or Konwa*)."—This salt was stated to have been obtained from French territory and to be worth, at Mongonu, 1*s.* per slab of 48 lb. The Chad natron is dug from an island or half submerged bank in the lake. The slab received for examination was of greyish-white colour.

No. 16. "*Chad Natron.*"—This sample consisted of about 45 lb. of greyish crystalline salt, the price of which was stated to have been 1*s.* *6d.* at Mongonu.

The samples were submitted to analysis at the Imperial Institute, and their approximate composition is shown on page 488.

The results of analysis show that all the salts of vegetable origin contain a good percentage of potassium chloride, the best in this respect being sample No. 1.

Sample No. 2, made in French territory from the ash of the kighr tree, contains about twice as much potassium chloride as the kegu salt (No. 3) made in British territory, but it compares fairly well as regards the composition of its soluble salts with a sample previously examined at the Imperial Institute (see *Second Report on the Mineral Survey of Northern Nigeria*, 1904–5, p. 5). Salt similar to sample No. 3 could, however, be utilised for the preparation of potassium chloride, if available in quantity. Sample No. 4, also, would be suitable for the preparation of potassium chloride, but it is stated not to be common.

The chief constituents of sample No. 5 are chlorides of sodium and potassium; a considerable amount of sodium sulphate is also present. The salt thus shows a wide variation in composition from that previously

No. of Sample.	Sodium chloride NaCl.	Sodium sulphate Na_2SO_4.	Sodium carbonate Na_2CO_3.	Sodium bicarbonate $NaHCO_3$.	Sodium phosphate Na_2HPO_4.	Potassium chloride KCl.	Potassium sulphate K_2SO_4.	Potassium carbonate K_2CO_3.	Calcium chloride. $CaCl_2$.	Calcium sulphate $CaSO_4$.	Magnesium chloride $MgCl_2$.	Magnesium sulphate $MgSO_4$.	Matter insoluble in water.	Moisture and combined water H_2O.
Vegetable origin														
1	9·62	0·73	—	—	—	81·16	—	—	—	1·92	—	—	1·17	5·07
2	26·83	0·67	0·22	—	—	57·88	—	—	—	—	—	—	11·89	2·11
3	67·60	1·42	—	—	—	28·76	—	—	—	1·48	—	—	0·36	0·37
4	49·01	—	—	—	—	43·43	—	—	0·61	2·14	0·35	—	0·51	3·30
5	37·46	21·51	1·95	1·52	0·11	35·46	—	—	—	—	—	—	0·48	1·65
6	34·71	26·84	3·81	0·76	0·21	30·92	—	—	—	—	—	—	0·30	1·72
Mineral origin														
7	41·61	—	—	—	—	51·12	—	—	1·25	2·02	—	—	0·45	3·55
8	37·36	40·84	9·93	3·82	—	3·23	—	—	—	—	—	—	3·72	0·69
9	20·86	17·70	5·01	0·38	0·12	3·80	—	—	—	—	—	0·33	49·41	2·95
10	61·51	23·17	2·44	—	—	7·72	—	—	—	—	—	—	2·88	2·12
11	43·94	27 85	—	—	—	10·00	—	—	—	—	—	8·55	7·42	1·82
12	—	97·70	0·36	—	—	0·42	0·50	—	—	—	—	—	0·19	0·37
13	0·35	2·72	58·69	12·87	0·05	0·44	—	—	—	—	—	—	0·19	25·12
14	3·10	3·34	31·90	24·36	0·24	3·74	—	—	—	—	—	—	16·43	17·03
15	—	—	43·51	34·37	—	0·71	0·54	0·16	—	—	—	—	2·54	17·87
16	—	0·37	45·48	34·57	—	1·03	0·11	—	—	—	—	—	—	—

The percentages of potassium salts in the different samples are equivalent to the following percentages of potash (K_2O): No. 1, 51·20; No. 2, 36·56; No. 3, 18·18; No. 4, 27·44; No. 5, 22·4; No. 6, 19·54; No. 7, 32·25; No. 8, 2·04; No. 9, 2·40; No. 10, 4·88; No. 11, 6·32; No. 12, 0·54; No. 13, 0·28; No. 14, 2·36; No. 15, 0·85; No. 16, 0·66.

examined at the Imperial Institute (see *Second Report on the Mineral Survey of Northern Nigeria*, 1904–5, p. 4), which had the following percentage composition: sodium chloride, 50·07; sodium sulphate, 29·39; sodium carbonate, 4·99; sodium phosphate, 5·45; potassium chloride, 2·54; boric anhydride, 1·36; water, 5·13; insoluble matter, 0·58. Sample No. 6 resembles No. 5 in composition, but contains rather less potassium chloride.

Of the salts of mineral origin, sample No. 7, from French territory, is of particular interest on account of the large percentage of potassium chloride present, and the locality from which the salt was obtained may for this reason be worth examination. It may be pointed out, however, that this sample of Sheri salt differs considerably from that previously examined at the Imperial Institute (see *Second Report on the Mineral Survey of Northern Nigeria*, 1904–5, p. 3), which consisted of sodium sulphate 40·05 per cent., sodium chloride 12·60 per cent., potassium chloride 0·77 per cent., matter insoluble in water 44·97 per cent.

Samples Nos. 8–11 consist chiefly of sodium chloride and sodium sulphate. Nos. 10 and 11, however, contain 7·72 and 10 per cent. of potassium chloride respectively, whilst the quantity of potassium chloride in No. 9, calculated on the soluble matter, is about the same as in No. 10. The presence of these quantities of potassium chloride in salts obtained from a mineral source renders the materials of some interest and it might be useful to make an examination of the localities in which the salt-impregnated earth occurs, in order to ascertain if there is any evidence of the existence of deposits of potash salts.

The salt represented by sample No. 12 consists almost entirely of sodium sulphate. It would be of little commercial value.

The chief constituents of samples Nos. 13–16 are sodium carbonate and bicarbonate, Nos. 15 and 16 consisting almost entirely of natron (Na_2CO_3, $NaHCO_3$, H_2O). No. 14, in which a large quantity of insoluble matter is present, contained 3·74 per cent. of potassium chloride, but this quantity is too low to render its separation a commercial possibility.

General Conclusions

Considered as possible sources of potash, samples Nos. 1–6 must be disregarded, since they are of vegetable origin, and the production will consequently be limited. Natron is the chief constituent of samples Nos. 13–16, and these materials would be useful for the manufacture of soap for local use. Sodium sulphate is the principal constituent of Nos. 8 and 12.

It would appear that the localities from which Nos. 9 and 11 were obtained might be worth examination, in view of the quantity of potash found in these samples. The same remark applies in the case of Nos. 7 and 10, but these samples were obtained from French territory. It would probably not be remunerative to produce potash from these salts for export, especially under present conditions, when European supplies of potash are again available; but, if obtainable in large quantities, they might serve as sources of potash for local use in West Africa.

GENERAL ARTICLES

THE PRODUCTION OF TEA IN THE EMPIRE AND ITS RELATION TO THE TEA TRADE OF THE WORLD

It is of great importance at the present time that the position of the production of tea in the Empire and of the tea trade of the world should be stated and explained. The present article has therefore been prepared by Mr. A. S. Judge, lately Chief Collector of Customs in Burma.

The Origin of Tea

The tea-plant, an evergreen belonging to the genus Camellia, is indigenous in the wild hilly country which separates India and Burma from China, and also in parts of Central and Western China. It is not known from what source the Chinese first obtained the plant for cultivation, as the variety now grown in China differs greatly from the indigenous plant discovered in recent times. The cultivated China plant has a small leaf and grows naturally

as a bushy shrub, whereas the Assam variety has a very large leaf, and, if allowed to grow naturally, develops into a tree; in the forests of Manipur large tea-trees have been found, some growing up to a height of one hundred feet.

From time immemorial the people of the Shan States and other localities have cultivated the tea-plant and pickled and eaten the leaves; the Chinese were, however, the first to discover the virtues of tea as a beverage. In the early years of the Christian era the Chinese were manufacturing and drinking tea, and in the eighth century the industry was of sufficient importance to make it liable to imperial taxation. The Japanese obtained tea-seed from China about the tenth century, and early acquired the tea habit. For many centuries tea-drinking was confined to China and Japan.

The Spread of Tea-drinking

The United Kingdom.—The Dutch first introduced tea into Europe, but no regular trade was established until the East India Company brought samples to London late in the seventeenth century. Coffee and cocoa were recognised beverages when tea was first introduced and sold to the public in the London cocoa and coffee houses. It was at first brewed in a cask and drawn off like beer, a tax of 1*s.* 6*d.* being levied on each gallon of liquid tea. For a long period tea was an expensive luxury. In 1819 the consumption in the United Kingdom was about 21,000,000 lb., or an average of 1 lb. per head. In 1833 the monopoly of the trade in tea, which the East India Company had held for 180 years, came to an end, and about the same time the cultivation of tea in India was started. As the price went down consumption advanced, but between 1836 and 1852 the high rate of duty, viz. 2*s.* 2¼*d.* per lb., checked progress. In 1865 the duty was reduced to 6*d.* per lb., which had a stimulating effect on the trade; in 1867 the average consumption was about 3 lb. per head, and Indian tea formed about 5 per cent. of the total quantity consumed. Twenty years later the consumption was twice as large, and more than half the supplies came from India and Ceylon. Many causes had contributed to the increase in consumption: the com-

petition of British-grown teas had forced down prices, freights were lower owing to the opening of the Suez Canal and to the introduction of steamers, and there was a wave of prosperity in the United Kingdom, and all classes could afford to buy tea. It was during this period that tea was universally used as a breakfast beverage. Between 1890 and 1900 the duty was only 4*d.* per lb., the distributing trade was thoroughly organised and tea was supplied in packets to suit all tastes. Afternoon tea became a national institution, and tea-shops to supply this want were multiplied. When the people had acquired the tea habit they were not satisfied with the common China teas, and by 1900 British grown teas had practically secured the home market. Since 1900 the consumption in this country has steadily advanced; during the war economy had to be exercised, but for the last two years the rate of consumption has been about 9 lb. *per capita*, which represents a daily allowance of four cups of tea for each individual.

The Dominions and India.—The Australians and New Zealanders are as great tea-drinkers as the people of the Mother-country, and they also have discarded China tea for the more refreshing and stimulating tea produced in India and Ceylon.

In Canada the average consumption of tea is about 5 lb. per head; a certain amount of China tea is still being imported, as well as green tea from Japan.

The Dutch in South Africa are not tea-drinkers, but the British in the Union consume a considerable quantity, a part of which is supplied by the tea plantations of Natal.

In India, owing to the excellent work done by the Tea Cess Committee, tea-drinking has been popularised in many localities, and in 1919 the consumption was estimated at 50,000,000 lb. As the material prosperity of the people is rapidly improving, this market should in future absorb much larger quantities of lower grade teas.

The United States of America.—In the United States the average annual consumption per head is only 1 lb. compared with 9 or 10 lb. of coffee. Green teas obtained mainly from China and Japan are largely used, although in recent

years Ceylon, Indian and Java teas have been making head-way. It is strange that the Americans should not have acquired the tea habit, as so many of them are descendants of emigrants from these islands, and tea was taken to America by the early colonists. The Americans know little about the virtues of tea ; coffee is very largely consumed, but tea has never been placed properly in competition with it. The efforts which have been made by the Indian Tea Cess Committee during the last 25 years to popularise Indian tea in America do not appear to have met with any success. The average *per capita* consumption of tea in the States at the outbreak of the war was less than it had been twenty years earlier. One of the American trade journals interested in tea recently pointed out that the tea used in most of the best hotels and dining-car systems of America was of such low grade and inferior quality, and was so imperfectly brewed that it was impossible to make tea-drinkers of the American public. The Tea Associations of the United States have started a publicity campaign throughout the country with the object of increasing the consumption of tea ; it is not intended to push the sale of any special kind of tea, but rather to educate the people to drink tea of good quality. The present time appears to be most opportune for such a movement, as Prohibition is now in force, and thousands of men who served during the war acquired the tea habit. This movement appears to be deserving of support from the tea-growers of India and Ceylon.

Russia.—Russia first obtained tea from China in the seventeenth century, and for many years, until the opening of the Siberian railway, there was a regular caravan trade in this commodity between the two countries. In recent years the Chinese supplies have come either by rail or by sea to Batoum, and those from India and Ceylon by steamer principally to Odessa and Vladivostok. Although the Russian market in normal times absorbs a considerable quantity of tea, the average annual consumption *per capita* has been about 1 lb. only. This is due to the fact that the bulk of the people are poor, and communications, except on the lines of railway, are bad. The poorer classes drink their tea weak, the tea-pot is filled with water several

times, until all the essence is drawn from the leaves. While the wealthy classes were drinking the finest teas produced in China or India, a large proportion of the imports was in the form of brick-tea, composed of poor China teas with an admixture of dust and fannings from the British and Dutch plantations. The tea habit is probably most general in the Central Asiatic Provinces of Russia, where green teas are principally used. In Russia itself and in Siberia there was a growing demand for the sound black teas produced in India and Ceylon ; this trade had reached considerable dimensions at the time of the outbreak of the war, and in 1915 and 1916, after the introduction of temperance legislation, the imports were the highest on record. The Russian market has temporarily been lost, but British trade should be able to recover the lost ground when conditions are more favourable.

The Continent of Europe.—Apart from Russia, comparatively little tea is drunk on the Continent, except in Holland, where, owing to her connection with Java, tea has been imported and used for a long time. Before the war Germany was slowly acquiring the tea habit, and was importing annually about 10,000,000 lb. of tea. Tea-drinking was also on the increase in Belgium and Denmark, and in many of the large towns and pleasure resorts on the Continent the afternoon tea custom, introduced by British visitors, was becoming a popular institution.

South America.—In Argentina and Chile considerable quantities of tea are drunk, and it should be possible to develop these markets still further. In South America generally Yerba maté, or Paraguayan tea, is the most popular beverage. The Yerba-tree, *Ilex paraguayensis*, is indigenous to Paraguay, the southern provinces of Brazil and parts of Argentina. The consumption of this tea has so greatly increased that large plantations have been established in the countries mentioned above. In 1918 Brazil exported 163,000,000 lb. of Yerba maté, valued at 3·4*d.* per lb. ; Argentina took 100,000,000 lb., and the balance went mainly to other countries in South America. The harvesting of the crop is very simple, all the leaves and small twigs on a tree are pruned, and, before fermentation can set in, are dried over

a fire in the same manner as tea-leaves are dried; the leaves are then ground into powder in a mill. Maté is prepared with boiling water like ordinary tea; the infusion has a bitter flavour, and is not so pleasant to the taste as tea. It is said to be a stimulating drink, but contains less caffeine than tea. The Brazilian growers of maté are searching for new markets for their product in North America, and on the Continent of Europe. This movement will have to be watched by those interested in tea.

Other Countries.—In Persia, Asia Minor, Arabia, Afghanistan, Morocco and North Africa generally the tea habit is spreading, green teas being most in demand.

The Descriptions and Qualities of Tea

Tea may be divided into two classes: (1) Black Tea; (2) Green Tea. The difference in the colour and character of the teas arises from the different methods of manufacture.[1] To obtain black tea the leaf, after being rolled, is allowed to ferment before being fired; the process of fermentation, or oxidation, reduces the astringency of the leaf, and at the same time develops the colour and aroma of the tea. In making green tea the fermentation is arrested by steaming the leaf when it is green, and subsequently rolling it lightly before drying. The liquor from black tea has more body and colour than that obtained from green tea, which is, however, more pungent. China and Japan supply the bulk of the green teas consumed in the world, and although India and Ceylon have been producing considerable quantities in recent years, British and Dutch plantations are mainly concerned in the manufacture of black tea. The teas known as Oolongs, which come principally from Formosa, have the character of green tea, and may to some extent be classed as such. The perfume of the scented teas, of which the Chinese are so fond, is not natural, but is imparted by the use of gardenia, jasmine, and other fragrant flowers during the process of manufacture. Brick tea is composed of either black or green tea which has been compressed into this form for the convenience of carriage, and also to save the cost of packing.

[1] Full details regarding the manufacture of tea will be found in this BULLETIN (1913, **11**, 270).

Tea in bulk soon deteriorates unless packed in hermetically closed receptacles, whereas compressed tea will preserve its character for a long period. The small-leafed China plant is grown principally in China, Japan and Formosa; it is also to be found in Darjeeling and other tea districts in the Himalayas, and in small native plantations in Java. This plant is not well suited to a warm climate. The large-leafed Assam variety, which gives a high yield of leaf, is now universally cultivated in the plains of India, and throughout Ceylon and the Dutch Indies.

The quality of tea depends largely on flavour, which is produced chiefly by the presence of a fragrant oil of a volatile nature, about which little is known at the present time. The finest flavoured teas are only produced in certain localities; some of the best come from Upper Assam and Darjeeling. A comparatively small quantity of these "stand-out" teas is produced. To produce such teas a combination of several conditions is necessary: the soil of the plantation and the "jât" (variety or strain) of the plant must be suitable; the climatic conditions at the time of production must be such as conduce to the slow growth of the shoots; and, finally, the leaf must be plucked fine and carefully manufactured. If the weather is not suitable, a garden which has been making choice teas will fail to maintain the highest standard. Moreover, it happens that a garden adjoining one of the favoured ones, while making good tea, will not be able to obtain stand-out flavour, although the jât of the plant and system of plucking and manufacture in the two gardens may be identical; in such cases it is evident that something is missing in the soil. That the slow growth of the leaf has a considerable bearing on the flavour of the tea is proved by the fact that some of the finest teas in the Darjeeling district are made when green-fly attacks the plant and checks the growth of the leaf, and also that during the autumn, when growth is naturally checked, some fine-flavoured teas are produced throughout Assam and the Dooars. During the rains, when growth is luxuriant and large quantities of leaf are produced, there is a falling off in quality due partly to the character of the leaf, and also to the difficulties experienced in the factory in dealing with excessive quantities of wet

leaf. In the plains of India generally, and in Ceylon and the Dutch Indies, except at the higher elevations, the quality of the tea depends mainly on the care exercised in plucking and manufacturing the leaf; good drinking teas are produced, but without fine flavour. At the higher altitudes in Ceylon, and also to some extent in Java, fine-flavoured teas are produced.

After tea has been manufactured it is sorted into grades by sifting; the best grade consists of the leaf-buds and delicate young leaves which are obtained at the first sifting of the tea. The buds and younger leaves possess in the highest degree all the good properties of the tea produced, and also the highest percentage of caffeine, the alkaloid which gives to tea its stimulating character.

The following statement shows the average price per lb., obtained at the London auctions in 1916, for teas from various localities; the values indicate only to a small extent the relative qualities of the teas produced in those localities, because during the war there was less difference between the values of common and fine teas than during normal periods.

	s.	*d.*		*s.*	*d.*
Darjeeling . .	1	1·13	Dooars . .	0	10·86
Assam . . .	0	11·63	Cachar and Sylhet	0	10·49
Ceylon . . .	0	11·29	Java . .	0	10·45
Southern India .	0	11·25	Terai . .	0	10·40

The following statement shows the average wholesale tea prices in New York in 1916 (cents per lb.).

	Lowest.	Highest.		Lowest.	Highest.
Foochow .	17½	21	India (Orange pekoe) .	28	30
Formosa .	23	39	Ceylon (Orange pekoe) .	28	30
Japan (Green)	16	35			

The Tea-producing Countries

The following countries supply the world with tea: China, Japan, Formosa, French Indo-China, India, Ceylon, Java, and Sumatra in Asia, and Natal and Nyasaland in Africa. In the Caucasus, near Batoum, a small tea industry is in existence; it was started some thirty or forty years ago, but has made little progress. In the United States of America exhaustive experiments were made by the Agricultural Department; it was proved, however,

that without plentiful and cheap labour the tea industry could not be made a paying proposition. The supply of labour is the most important question in regard to the cultivation of tea, more than twice the number of coolies being required to work a tea estate as would be necessary to work the same acreage under coffee or rubber. A large proportion of the labour on a tea estate should also consist of women and children for leaf-plucking; if men are employed in this work the cost of production is greatly enhanced. The labour question is a cause of anxiety to planters in all parts of India, Ceylon and the Dutch Indies, and further extensions of tea in any of these localities will only be made after mature consideration. The shortage of labour for leaf-plucking, especially in tropical climates where growth is rapid and luxuriant, is a very serious matter. If all the leaf is not taken off when ready to be plucked the shoots run away, especially in the centre of the bush, and not only is the plucking surface of the bush reduced, but when a bush has put on a certain amount of foliage it will not continue to "flush" so freely and the yield of leaf falls off. At the present time the aim of the planter is to obtain the best results from the area already planted; this can be effected by improved methods of cultivation and pruning, and by gradually replacing plants of inferior jât by those which will give the highest yield of leaf.

China.—Tea is cultivated in several provinces of China, the region of greatest production being the coastal and interior provinces bordering and immediately south of the Yangtze-kiang—it is in this region that the black and green teas of international commerce are produced. In Yunnan also there is a considerable cultivation, but the plant grown is the large-leafed indigenous variety, and the tea produced is used in Western China and Tibet. In China, tea is grown in small patches round the homesteads of the peasant proprietors, large plantations being practically unknown. The severity of the winter climate, together with the none too abundant rainfall, causes the plant to flush, or produce shoots so slowly that only three or four pickings can be made between April and October. The finest teas are produced in April, when the young leaves and buds are covered with a white down. The leaves are

picked and partially cured by members of the grower's family; they are then collected by a middleman, who subjects them to a process of firing before sending the product in bulk to one of the large centres, where factories have been established for refiring, sorting and packing. The chief centres of the tea trade are Hankow for brick tea and black tea, Kiukiang, Santuao and Foochow for black and green tea, and Hangchow and Ningpo for green tea. Yachau is the centre for the trade with Tibet.

There are no reliable data regarding the quantity of tea produced in China; more than 300,000,000 lb. have been exported in one year, the average shipments in recent years being about 200,000,000 lb. The exaggerated estimates which have been made regarding the production of tea have evidently been based on the statement, published in the *China Year-book*, that the local consumption of tea is estimated at 5 lb. *per capita*; on this basis the production would amount to 2,200,000,000 lb. Although tea is drunk universally in the tea-growing regions and in the large towns, there are many parts of China where the poor circumstances of the people, lack of communications and cost of transport must seriously restrict consumption. The Chinese, moreover, are very economical in the use of tea, and even the prosperous Chinese communities in Malaya and Burma, for whose use tea is imported from China, hardly use an average of 5 lb. a head annually. In these circumstances it is impossible to frame any reliable estimate of the production of tea in China; but, whatever the amount may be, it is quite evident that the quantity available for export is not unlimited, and that, with an advance in the material prosperity of the people, and with an improvement in the means of communication, the local demand for tea will increase.

In 1886 China supplied the bulk of the tea consumed in the world. Since that period the consumption of tea, outside China, has more than doubled, but China's contributions to the trade have receded by 100,000,000 lb., notwithstanding the fact that in pre-war years over 30,000,000 lb. of common teas were imported every year from India, Ceylon and Java to be blended with the local product in the manufacture of brick-tea for the Russian

market. China has also been importing about 2,000,000 lb. of Formosa tea every year for home consumption. Although China produces some teas of fine delicate flavour, the bulk of the exports is of poor quality, and it would appear that fine teas do not form a large percentage of the total production.

The exports from China are shown in the Customs returns under the following heads: black, green, black brick, green brick, tablet, and dust. Between 1912–14 the average quantity of each description exported was as follows:

Description.	Quantity. *lb.*	Percentage of total exports.	Average value per *lb.* taking value of tael at *2s. 8d.* *s. d.*
Black tea	80,418,000	41·1	0 8·6
Green tea	37,966,000	19·3	0 11·9
Black brick tea	75,394,000[1]	38·5	0 5·4
Green brick tea			0 2·6
Tablet	1,140,000	0·6	0 6
Dust	962,000	0·5	0 1·9
Total	195,880,000	100·0	0 7·46

[1] *In nearly equal proportions.*

The above statement does not include the trade with Tibet.

The annual amounts sent to the principal customers during the period 1912–14 were as follows:

Country.	Quantity. *lb.*	Percentage of total exports.
Russia	114,372,000	58·3
United States of America	20,970,000	10·7
United Kingdom	13,990,000	7·1
Hong Kong	12,691,000	6·4
France	8,221,000	4·4
Germany	6,018,000	3·1
Other countries	19,618,000	10·0
Total	195,880,000	100·0

Russia took practically all the brick and tablet teas; the chief markets for green teas are the United States, Central Asia, Persia and Morocco, whilst black teas are more generally distributed.

In 1919 the aggregate exports were about 92,000,000 lb. —an improvement on the trade of 1918, which amounted to only 54,000,000 lb. The decline, as compared with pre-war exports, was mainly due to the uncertain Russian

market, and also to the unfavourable exchange. In 1919 over 27,000,000 lb. were sent to London, the Mecca of tea, which was more than twice the average quantity shipped during pre-war years. In an effort to encourage the tea trade, the Chinese Government, in October 1919, abolished the export duty levied on all teas shipped abroad.

French Indo-China.—Tea has been grown by native cultivators in Indo-China for many years, and has been exported in small quantities, mainly to France, since 1900. In recent years the exports have amounted to nearly 2,000,000 lb. The China variety of the plant has been cultivated and the tea produced has been of poor quality. It is stated that, in Tonkin and Central Annam, Europeans are growing tea, and, as the climate is suitable and labour should be cheap and plentiful, it will be interesting to watch the development of this industry. The large-leafed tea-plant is said to be indigenous in the hills of Tonkin.

Japan.—There is a large area under tea in Japan, grown principally in small plots ; the production must be considerable, as tea is universally consumed in the country. Green teas are mainly manufactured, and for many years Japan has supplied America with tea ; in recent years this trade has amounted to about 35,000,000 lb. The competition of British and Dutch grown teas in the United States is now very keen, and Japanese merchants are making great efforts to retain, and if possible to extend, their trade.

Formosa.—The tea-plant was introduced into Formosa from China more than a hundred years ago. The cultivation is carried on, as in China and Japan, by peasant proprietors, who also manufacture the tea and sell it to central factories, where it is refired, sorted and packed. The Japanese authorities have encouraged the industry, and there is now a considerable export trade, which does not, however, appear to increase. Formosa Oolong teas are said to have a distinctive flavour, and are very popular in the United States, where they obtain good prices (cf. p. 497). The annual exports amount to about 25,000,000 lb., and America is the best customer.

India.—*General.* The question of growing tea in India was taken up by the Government in 1834, and an official was sent to China to study the conditions prevailing there, and also to obtain seed. A variety of the tea plant was known at the time to be growing wild in Assam. The seed obtained from China was distributed in certain of the Himalayan districts of Northern India, in the Nilgiris and other hill districts of Southern India, and in Assam. For some years seed continued to be imported from China, as the experts unfortunately did not recognise the merits of the indigenous variety. The first sample of tea made in India was prepared, however, in 1837 from old plants found growing on a tract of land in Lakhimpur, Assam, which had been cleared for cultivation. The tea-plants and other trees on the land had been cut to the ground and the land cultivated and planted with rice. After the paddy had been cut it was noticed by a Mr. Bruce, a government official, that the tea plants had thrown out young shoots and leaves. It was from this accidental discovery of the expediency of cutting down the plants in order to improve the quality of the foliage that leaf was obtained for the manufacture of tea, of which about 500 lb. were shipped to England in 1838. From the fact that tea-plants were found growing in small patches in various parts of Assam, it would appear that the former inhabitants of the country had cultivated the plant for the manufacture of let-pet, or pickled tea, as is done to this day by the neighbouring Shans in Burma. At the time of the British occupation of Assam the country had been laid waste and depopulated by the incessant raids made by the Burmese.

The pioneer tea company formed in India was the present Assam Company, which took over in 1840 the Government experimental garden in Lakhimpur. For some years the industry was confined to Upper Assam, the Kumaun and the Nilgiris, the impression at that time being that tea must be grown on the slopes of hills. In 1856 the tea-plant was found growing wild in Cachar, and land was taken up for tea, and tea-planting was simultaneously started in the Darjeeling Hills. In the sixties there was a wave of speculation, and new estates were

opened up in many directions; it was during this period that tea was planted in the plains in the Darjeeling Terai, Chittagong, and Chota Nagpur. Many of the new companies were floated by inexperienced persons, and without sufficient capital, and there were consequently many failures. After this set-back the industry was organised on much sounder lines by various Calcutta firms; during the seventies great progress was made, and machinery for rolling, firing, and sorting the leaf began to be introduced.

The following statement shows the progress made since 1878:

Year.	Area.	Production.	Percentage of increase over previous decade.		Yield per mature acre.
	Acres.	*lb.*	*Acres.*	*Yield.*	*lb.*
1878 .	199,132	38,665,000	—	—	260
1888 .	325,313	99,791,000	62·9	158·0	344
1898 .	500,450	157,251,000	54·3	57·5	381
1908 .	548,627	247,024,000	9·6	58·3	475
1918 .	675,718	380,348,000	23·7	54·0	609

The following statement shows the distribution of tea in the various Provinces of India in 1918—Burma has been omitted, as the tea-plant is cultivated there mainly for the production of let-pet:

—	Assam.		Bengal.			Bihar and Orissa.	United Provinces	Punjab.	Madras.	Travancore State.	Total.
•	Brahmaputra Valley.	Cachar and Sylhet.	Darjeeling Hills and Terai	Dooars.	Chittagong.	Chota Nagpur.	Dehra Dun, etc.	Kangra Valley.	Nilgiris, Malabar, Coimbatore, etc.		—
Area, acres .	254,754	151,197	55,416	108.197	5,495	2,178	7,987	7,508	38,528	44,458	675,718
Production (thousands of lb.) .	171,686	81,584	19,443	68,685	1,855	324	2,235	1,389	10,518	22,629	380,348
Yield per mature acre, lb. .	725	556	364	684	378	150	280	185	450	572	609

The principal tea districts are situated in North-Eastern India, in the Provinces of Assam and Bengal, and contain 84·5 per cent. of the aggregate tea acreage in India. Calcutta is the headquarters of the Agencies controlling the tea industry of this area, and the bulk of the tea is shipped from this port, and the balance from Chittagong.

Southern India—Madras and Travancore—contains 12·2

per cent. of the planted area. The industry in these localities is of comparatively recent growth, and is controlled by Agency houses established in Madras and other Southern India ports from which the tea is shipped.

The share capital of 50 of the leading Indian Tea Companies, registered in London and controlling 254,647 acres of tea, amounts to £11,558,555, or an average cost of about £40 per acre. If £20 per acre is taken as the capital cost of the remaining planted area of 421,070 acres, the aggregate amount invested in the Indian tea industry would be £20,000,000.

The following statement shows the results of working of fifty leading Indian tea companies in 1915:

Total share and debenture capital.	Area under tea.	Capital cost per acre.	Crop.	Average yield per mature acre.	Average sale price per lb.	Average all in cost per lb.	Divids. and debenture interest.	Reserve funds.	Rate of interest on ordinary shares.
£	*acres.*	£	*lb.*	*lb.*	*pence.*	*pence.*	£	£	*per cent.*
11,558,555	254,647	40	172,567,730	720	10·65	6·90	1,565,920	2,806,248	13½

The above results were obtained when the rupee was worth 1*s.* 4*d.*; at this rate of exchange the cost of production was 6·90 annas, or 6·90 pence, per lb. The following table shows what would have been the results of working the above companies with the rate of exchange at 1*s.* 8*d.* and 2*s.* per rupee respectively. It has been assumed that the London charges paid in sterling amounted to 0·90*d.*, and the balances of the expenses were incurred in India and paid for in rupees:

	Sale price per lb.	Cost of production per lb.	Profit per lb.	Profit.
	pence	*pence*	*pence*	£
Exchange at 1*s.* 4*d.* . . .	10·65	6·90	3·75	2,696,560
Exchange at 1*s.* 8*d.* . . .	10·65	8·40	2·25	1,617,698
Exchange at 2*s.*	10·65	9·90	0·75	538,677

Since 1915 the actual cost of production has gone up considerably, the wages of labour, cost of stores, and freight charges are all much higher. There is little hope that any appreciable reduction can be made in the cost of production, irrespective of the question of exchange. Tea in future must cost more; the only relief the consumer can look for is by a reduction in the rate of duty.

The cost of production varies in the different tea districts; it is highest in Darjeeling and Assam, and lowest in Southern India, the Dooars and Sylhet. The high cost in Assam is due mainly to labour charges, and in Darjeeling to the low average yield per acre.

The average annual production of tea in India for the five years 1915–19 was 375,000,000 lb., an increase of about 85,000,000 lb. over the average crops of the preceding five years. The crop of 1920 was a short one, owing to unfavourable climatic conditions, especially in the Terai and Dooars, where the output in many estates was from 25 to 40 per cent. less than in 1919. Production was also restricted towards the end of the season, when common teas were selling at Calcutta under two annas a pound, which barely paid for the cost of packing. It has been recommended by the Indian Tea Association that the output for 1921 should be reduced by 20 per cent., which would limit the Indian production to about 300,000,000 lb. Unless the prices of common teas improve, however, it is doubtful whether estates producing mainly this class of tea can continue working at a loss.

The following table shows the distribution of the Indian exports for five years (thousands of lb.):

Country.	1914–15.	1915–16.	1916–17.	1917–18.	1918–19.
United Kingdom	237,304	250,290	224,928	266,963	282,205
Russia	19,636	36,590	27,604	8,122	—
Continent of Europe	917	232	123	1,028	1,802
Egypt	686	995	1,081	6,226	601
Union of South Africa	160	570	724	4,311	1,889
Other countries in Africa	566	795	589	905	910
Canada	10,951	8,842	8,443	21,153	926
United States	2,737	3,443	3,032	20,665	1,852
Argentina	—	—	—	353	343
Chile	218	942	1,736	1,604	4,163
Other countries in America	11	12	6	144	337
Ceylon	3,293	4,307	3,647	4,484	1,283
Aden and Arabia	1,082	2,099	884	2,834	2,557
Persia and Turkey-in-Asia	3,279	9,203	2,746	5,463	16,343
China (for Russia)	8,309	9,864	9,304	3,245	621
Other countries in Asia	632	715	1,432	916	434
Australia, New Zealand	10,990	9,591	5,160	10,776	7,397
Total exports by sea	300,771	338,490	291,439	359,192	323,663
Total exports by land	1,785	1,943	1,155	1,440	2,982
Grand total	302,556	340,433	292,594	360,632	326,645

Under an Act passed in 1903, Indian teas exported are subject to a cess of ¼ pie per lb. for the purpose of propaganda to encourage the use of the beverage. The Tea Cess Committee have recommended that the amount of the cess should be increased, as the funds now raised, which amounted to Rs.4,51,000 in 1918–19, are wholly required for furthering the consumption in India. In addition to the duty levied under the Indian Tea Cess Act, an export duty of Rs.1·8 per 100 lb. (equivalent to about 3 pies per lb.) has been imposed with effect from March 1, 1916. The amount of export duty collected during 1918–19 was Rs.43,86,000.

The exports of tea fluff, or tea waste, from India have exceeded 7,000,000 lb.; it goes principally to the United States, where it is used for the manufacture of caffeine.

In 1918–19 India imported about 11,500,000 lb. of tea, of which 2,500,000 lb. were re-exported, and the balance retained for consumption. Ceylon supplied over 6,000,000 lb. of low grade teas for use on the West Coast of India, and China sent more than 4,000,000 lb.—a part of which was re-exported.

According to the official returns 783,000 persons were employed in the industry in 1918; this would give 115 coolies for 100 acres of tea.

Assam.—Tea is grown to perfection in Assam, the natural home of the plant, not only as regards quantity, but also as to quality. For many years China seed was planted and in 1882 the average yield per acre was only 290 lb., whereas the more recently planted estates in the Terai and Dooars were producing 400 lb. The China plant has now disappeared, and been replaced by the finest varieties of the indigenous plant raised in various seed gardens established in Assam. These gardens have supplied nearly all the seed used in recent years in India, Ceylon and the Dutch Indies. The yield has been enormously increased, and the average per acre from 236,000 acres plucked in 1918 was 725 lb., and there are many large estates producing over 800 lb. of fine tea per acre. Two companies, Budla Beta and Pabbojan, famed for the high quality of their produce, had in 1919 an average yield

of over 900 lb. of tea per acre from a planted area of 4,656 acres. There are large areas of waste land suitable for tea in Upper Assam, but future extensions must depend on the available labour supply. Tea garden labour is recruited principally in Chota Nagpur, Orissa, and the Central Provinces, and, with the industrial development of India, the competition for this labour is becoming very keen.

Cachar and Sylhet.—Tea was first planted in Cachar on low hills, known as teelas. In laying out the estates no attempt was made to conserve the surface soil, which was in consequence washed away in a few years, and a large number of the teela gardens were abandoned. In the seventies, tea was planted on the flat lands lying between the hills; these flats, or "bheels," are swamps or bog land, composed often of true peat. Bheel lands have a very rich though shallow surface soil, with an impervious subsoil; the bushes, therefore, always have their roots in the surface-soil. Excellent yields have been obtained from some of the bheel gardens; the quality of the tea is, however, always poor. It seems doubtful whether the tea-plant, with stunted root developments, will have a long life in shallow soils. Tea has also been extensively planted in the plateau lands of Cachar and Sylhet; the soils are not equal to those of Assam, and the quantity and quality of the crops are inferior to those obtained in Assam or the Dooars. The tea industry of this locality is very seriously affected by the great fall in the price of common teas, and it also feels most acutely the competition of the low grade tea produced in the Dutch Indies, which can be landed and sold at a much lower cost. In 1916 the Sephinjuri Bheel Company had an average yield of 898 lb. of tea per acre, and the cost of production was 5·80*d.* per lb.; this was when the exchange was 1*s.* 4*d.* to the rupee; since then expenses have gone up, and are now from two to three pence per lb. higher than in 1916.

Darjeeling.—The teas from the Darjeeling Hills are famous for their flavour, certain gardens producing "stand-out" teas for which high prices are paid in London. A few years ago the district produced generally delicately

flavoured teas, light in liquor, which were drunk by themselves ; now, however, the demand is for teas for blending, and the system of manufacture has been changed in order to obtain stronger teas. All the land suitable and available for tea in the hills has been taken up, and no further extensions can be made. By improved cultivation the average yield per acre is being steadily raised, and many estates produce over 500 lb. of fine tea per acre.

Terai.—A considerable area in this district was planted up in the eighties, but few extensions have since been made. Mosquito blight, combined with an unhealthy climate, have been the most serious drawbacks in the Terai. Tea can be produced at a fairly low cost, but the quality is not high.

Dooars.—Tea planting was started in the Dooars about 1878, and has made great progress since the fine lands in the Western Dooars were discovered. Very high yields, up to 1,000 lb. per acre, are obtained, and the average quality of the tea is good. There are large areas of excellent tea land available, which will be brought into cultivation as the occasion arises.

Southern India.—China seed was planted in the Nilgiris in 1834, and for many years the cultivation, on a small scale, was confined to the highlands. During the present century about 30,000 acres have been planted in the Nilgiris and adjacent districts, and about the same acreage in the Travancore State. The climate differs from that of North-Eastern India, and corresponds with the conditions prevailing in Ceylon. Good yields are obtained, and the quality of the tea is being improved. The plantations in Southern India have the advantage of a large local labour supply. The industry has been a success, and can be extended.

The remaining tea districts in India call for no remarks ; new extensions are not being made, and in some localities tea is gradually going out of cultivation.

Ceylon.—Tea-planting was only taken up in Ceylon about 1875, when leaf-blight (*Hemileia vastatrix*) in an epidemic form attacked the coffee plant. The coffee plantations covered an area of 275,000 acres, and within a few years these estates were transplanted with tea.

The following figures show how rapidly the industry was developed:

Year.	Planted area. Acres.	Exports. lbs.
1875	1,080	—
1885	152,000	4,500,000
1895	305,000	90,000,000
1905	390,000	170,183,000
1915	409,000	215,363,000

About 1904, rubber planting was taken up and large areas of tea in the low country were interplanted with rubber, and the tea eventually disappeared. At the same time, however, tea continued to be planted in the highlands, and during 1906–17 over 15,000 cwts. of tea-seed were imported from India, sufficient to plant out 45,000 acres. In 1920 it was estimated that there were 395,187 acres under tea, of which 366,678 acres were in bearing. The production was estimated at 192,500,000 lb., which would give an average yield of 525 lb. per acre. The out-turn from the native-owned gardens was estimated at 7,818,000 lb. At one time the average yield per acre in Ceylon was much higher than in India; this is, however, not so at the present time. While there has been a steady advance in the yields obtained on Indian plantations, in Ceylon there appears to have been a decline. Dr. Bernard, who was deputed in 1912 by the Government of Java to study the conditions of the tea industries of India and Ceylon, stated in his report that the absence of terraces on the Ceylon tea estates had resulted in a serious loss of soil so that on many estates more manure had to be used than would otherwise have been necessary in order to obtain a satisfactory crop. The above remarks do not apply to the fine estates opened out in Nuwara Eliya, and other districts on new lands, from which large yields of fine teas are obtained. There is no cold weather season in Ceylon, as in North-Eastern India, when the bushes are rested and pruned; the leaf is plucked throughout the year, and the bushes are pruned at intervals. The labour for the tea estates is recruited in Southern India, and, so far, there has been a sufficient supply. The cost of production has risen considerably since the war, and many estates have been seriously affected by the great fall in prices for common

teas, and by the competition, especially in Australia, of Java teas.

The following statement shows the exports of tea from Ceylon from 1917 to 1920:

	1917.	1918.	1919.	1920.
	lb.	lb.	lb.	lb.
United Kingdom .	85,363,000	93,477,000	140,283,000	119,496,000
Russia . .	10,298,000	156,000	761,000	—
Other countries in Europe . .	5,474,000	7,520,000	7,006,000	1,974,000
Australasia . .	29,478,000	35,522,000	18,114,000	22,888,000
America . .	35,785,000	15,546,000	26,005,000	24,384,000
China . . .	5,523,000	1,553,000	591,000	280,225
Other countries .	21,109,000	26,865,000	15,678,000	15,825,000
Total . .	193,030,000	180,639,000	208,438,000	184,847,000

Natal.—The tea industry of Natal dates from 1878, when coffee failed. At first good progress was made, and in 1903 the output was 2,681,000 lb. from about 4,000 acres in bearing. The restrictions placed on Indian immigrations into Natal in 1911 seriously hampered the industry, which has contracted and is being replaced by the cultivation of sugar-cane. The production in 1918–19 was 1,410,000 lb. from 4,136 acres.

Nyasaland.—Tea is grown only in the Mlanje district, where the soil and climate are well suited to the plant. It comes into profitable bearing in the fifth year, and tea can be produced at a cheaper rate than in India or Ceylon. In 1919 about 4,500 acres had been planted and about 700,000 lb. of tea were exported. The tea produced is of fair quality and there is a plentiful local supply of labour.

Java.—The Dutch introduced the tea-plant into Java in 1728, but tea-growing on a commercial scale was not started until 1826, when the Government imported and distributed seed from China among the native cultivators. Up to 1860 the industry was practically controlled and subsidised by the State as the production had to be made over at a fixed price, which was generally higher than the price at which Government sold the teas at Amsterdam. The industry, when left to private enterprise, made little progress until facilities were given in 1870 for obtaining land on long leases and planting was possible on the lines which were proving so successful in India. The early

plantations were opened out with China seed, and the tea produced was of poor quality. In 1878 Assam seed was first introduced, and in recent years all planting has been carried out with the best seed procurable. At the close of the nineteenth century the industry was on a sound footing and was attracting fresh capital. Within the last fifteen years great progress has been made, and many new companies have been formed with capital largely provided by the British public. The total area under tea at the present time must be considerably more than 200,000 acres. The large imports of tea seed from India show how rapidly the industry has been developed during the last ten years.

Imports of Tea-seed into Java from India

Period.	Quantity. cwts.
1900–06	3,532
1907–11	8,715
1912–16	25,362
1917–19	2,039
Total	39,648

In the early period seed was also imported from Ceylon, and the Java seed gardens are now supplying large quantities of excellent seed. A hundred-weight of tea seed comprises between 14,000 and 15,000 seeds, sufficient to plant and maintain three acres of land.

The following statement shows the growth of the export trade:

Year.	Exports. lb.
1899	12,842,000
1905	25,500,000
1909	36,678,000
1914	71,328,000
1919	110,772,000

There is a considerable consumption of tea in Java; some of the lowest grades of plantation tea are used locally, and tea made on the native gardens is not allowed to be exported.

Tea is grown mostly in the mountainous districts on the western side of the island; a large proportion of the area is cultivated by native proprietors, and consists of small gardens of a few acres in extent. These gardens are usually to be found in the vicinity of European plantations

where the green leaf is sold. The extent of the native cultivation may to some degree be estimated by the fact that in 1917 the total production of the Java plantations was 96,000,000 lb., whereas in 1918, when trade conditions were difficult and the planters refrained from buying native-grown leaf, the production fell to about 79,000,000 lb. In 1919, when conditions improved and Kampoeng, or native leaf, was again purchased for manufacture, the production rose to 94,000,000 lb. At the annual meeting of one of the Java tea companies held in London in October 1920, the chairman, after mentioning that the Indian and Ceylon growers were contemplating the adoption of measures to reduce their crops, added that " Java, though possibly not by the same methods, intends to take measures which should result in smaller crops." If the methods referred to mean that native leaf will not be purchased for manufacture then the Java industry will not be making the same sacrifice as the plantations within the British Empire.

Dr. G. D. Hope, Scientific Officer of the Indian Tea Association, who visited Java in 1916, has written a very instructive account of the Java tea industry. He writes in the highest terms of the excellent manner in which the Dutch planters have laid out their estates on the sides of the hills, and, by terracing and planting along contour lines of the slopes, have prevented loss of surface soil by wash. He also refers to the general superiority, from an agricultural point of view, of the soils of Java over those of North-Eastern India. The soils are richer in organic matter and nitrogen, but contain considerably less potash than the soils of the Indian tea districts, which would account for the fact that the greater proportion of the Java teas are of a common medium description. They are, however, carefully manufactured, evenly sorted in lots or " breaks," and put down at a low cost, which appeal to the blender. At the higher altitudes tea of good quality and flavour is produced. Java has a forcing climate, and there is little variation in the temperature throughout the year. In Java, as in Ceylon (see p. 509), there is no prolonged cool and dry period as in North-Eastern India, when the bushes are rested and pruning operations carried

out. In Java the bushes are plucked all the year round, and, as there is no fixed season for pruning, at any period of the year a part of an estate is being or has been recently pruned. References have been made to the very high yields obtained in Java, yet the average yield per acre, from the whole area under tea, does not appear to be so high as the average yield in India. Dr. Hope considers that the absence of a cold weather season is definitely objectionable. There are also labour troubles to contend with, which would account for the comparatively small crops obtained; estates depend mainly on neighbouring villages for their labour, which is not always available when the villagers are engaged in planting or harvesting their own crops. If tea bushes are not regularly plucked they get out of hand, and the yield of leaf falls off. The chairman of the Anglo-Dutch Plantations of Java, at the annual meeting held in November 1920, referred to the shortage of labour in the Company's tea estates, and stated that they were not desirous of extending their tea acreage, as they appeared to have drawn on the labour force in the hills to its fullest capacity. It seems improbable that any large extensions will be made in Java for some time to come, but the general tendency will be to attract labour to the existing estates and by this means to obtain larger crops.

Java can produce tea more cheaply then either India or Ceylon. The chairman of the Anglo-Dutch Plantations of Java estimated the present cost of production at 5*d.* per lb.

The following statement shows how Java teas are distributed:

Exports

Name of Country.	1913. *lb.*	1917. *lb.*	1918. *lb.*	1919. *lb.*
Holland	24,851,000	1,406,000	1,087,000	55,415,000
United Kingdom	21,770,000	3,735,000	—	27,240,000
Russia	4,839,000	18,784,000	1,815,000	—
Singapore (for Russia and China)	1,891,000	1,122,000	548,000	1,027,000
Australia	5,432,000	11,629,000	11,387,000	16,010,000
Canada } United States }	404,000	35,825,000	9,154,000	1,398,000
			35,831,000	5,022,000
Other countries	5,516,000	7,735,000	2,031,000	4,660,000
Total	64,703,000	80,236,000	61,853,000	110,772,000

It will be for the good of the tea trade generally if the preferential duty in favour of British-grown teas in this country results in the finding of other markets for Java teas. There is a growing trade with the United States which will be encouraged by the establishment of a regular line of steamers between New York and Java ports; although there was a decline in 1919, the trade rose again in 1920. Java is seriously competing with Ceylon in the Australian markets, where tea is admitted free of duty. Up to November 1920 the exports of tea from Java to Australia had exceeded 20,000,000 lb. and as these teas can be landed and sold in Australia at from *2d.* to *3d.* a lb. cheaper than Ceylon teas, the trade of the latter country has been seriously affected. The Government of Ceylon have asked for preferential treatment for British-grown teas, and it is understood that the question of giving preference to Indian and Ceylon teas will be considered when the Tariff proposals come before the Commonwealth Parliament. The exports to Holland were larger than the quantity required for home consumption; it is not known whether markets were found for the surplus.

Sumatra.—Tea cultivation was introduced in Sumatra in 1910, and at the present time it is estimated that there are 20,000 acres under the crop. There are a number of estates in the district of Siantar on the East Coast, the majority of which belong to British companies. Tea is also being cultivated on the Padang highlands on the South-Western Coast by Dutch planters. Dr. Hope, who visited the Siantar district, reports that tea grows remarkably well, and the district may become an important tea-growing centre. He mentions, however, that the soils are not in all respects first-class tea soils, the impervious nature of the subsoil, and the ease with which the surface soil suffers wash being the chief drawbacks. One of the characteristics of the tea-plant is the depth to which the tap root will grow; in Sumatra, however, the root growth of tea bushes is shallow, as the subsoil is not a satisfactory medium for it; the lateral roots spread out horizontally when they have reached a depth of not more than a foot, and the tap-root ceases as such altogether. Dr. Harold Mann, in a report on the tea soils of Cachar and

Sylhet, makes the following remarks regarding certain soils in which the root development of the plant is stunted: "Though the plant may be exceedingly luxuriant so long as the superabundant fertility of the surface soil lasts, it becomes, after this, exceedingly subject to drought, and the quality during its whole life reveals the unnatural conditions under which it is grown."

The growth of the bushes is very vigorous, and as much as 1,200 lb. of tea per acre has been produced in the fourth year after planting. The actual production of tea, however, in 1919 was 8,818,500 lb. from 13,500 acres in bearing, equal to an average yield of 670 lb. per acre. This compares unfavourably with the production in Upper Assam, where the average yield of 236,000 acres plucked in 1918 was 725 lb. The comparatively low yield obtained in Sumatra, where the best yielding Assam varieties of the tea-plant are grown and plucked all the year round, and where the growth is more luxuriant than in Assam, can only be due to a shortage of labour. There is practically no local labour, the bulk of the coolies coming from the thickly settled districts of Java on three years' contract. The cost of labour, and consequently the cost of production of tea, is higher in Sumatra than in Java. The Anglo-Dutch Plantations of Java, with large concessions of land in Sumatra, are not planting any tea there; the chairman, at the last annual meeting, gave as the reason for this policy that there was at present a lack of an adequate supply of labour, especially of children, in Sumatra.

The quality of the tea produced corresponds to ordinary Java teas. The following statement shows the distribution of the crop:

Exports

Name of Country.	1917. lb.	1918. lb.	1919. lb.
Holland	—	—	3,814,000
United Kingdom	986,000	96,000	3,946,000
Java	549,000	350,000	217,000
Singapore	237,000	4,150,000	1,211,000
U.S. America, Canada	2,064,000	670,000	141,000
Other countries	113,000	—	39,000
Total	3,949,000	5,266,000	9,368,000

Production and Consumption and the International Trade in Tea

Fifty years ago China and Japan produced practically all the tea consumed in the world; the tea industry of India was still in its infancy, and was emerging from a period of severe depression; the native cultivators of Java were growing tea in small patches, but large plantations equipped with factories had not then been established; Formosa was an unknown quantity, and Ceylon was still growing coffee. In 1870 the volume of the international trade in tea was about 300,000,000 lb., the bulk of which was supplied by China, India's contribution being under 15,000,000 lb. The United Kingdom consumed 120,000,000 lb., or 40 per cent. of the total quantity; the United States took 60,000,000 lb., or 20 per cent.; and Russia absorbed the largest share of the balance of the trade.

Twenty years later, in 1890, the Indian tea industry, with a planted area of 350,000 acres, was seriously challenging China's monopoly; the planting industry of Java had also made some progress. It was in Ceylon, however, that the greatest advance was made; as already mentioned, when coffee failed in the seventies attention was turned to tea, and, between 1878 and 1890, coffee estates extending over an area of 200,000 acres were converted into tea plantations. The trade of Formosa was developed during this period, and Japan also established an export trade in tea.

The World's Trade in 1890

Country.	Exports. *lb.*	Percentage of total trade.
British India	115,000,000	23·3
Ceylon	49,000,000	10·0
Java	7,500,000	1·5
China	250,000,000	50·9
Japan	50,000,000	10·0
Formosa	20,000,000	4·0
Other countries	1,500,000	0·3
Total	493,000,000	100·0

Country.	Consumption.[1] *lb.*	Percentage of total trade.
United Kingdom	195,000,000	40·0
Australia	25,000,000	10·0
New Zealand	4,000,000	
Canada	19,000,000	
United States	84,000,000	17·0
Russia	90,000,000	18·0
Continent of Europe (excluding Russia)	20,000,000	4·0
Other countries	56,000,000	11·0
Total	493,000,000	100·0

[1] *Consumption in the producing countries is not shown.*

In 1890 the tea plantations of India and Ceylon were in a flourishing condition, a good quality of tea was being produced which was becoming more popular in the British markets than the supplies obtained from China, and there was in consequence a ready market for their produce. The area under cultivation in the two countries was rapidly extended, between 1890 and the close of the century about 160,000 acres being planted in India, and 150,000 acres in Ceylon. In Java also there was much activity, but not on so large a scale, as British capital had not then been attracted to the Dutch Indies. The rapid increase in production, due to the competition between India and Ceylon, resulted in over-production, and in a great fall in prices before the close of the nineteenth century. This depression, with low prices, lasted until 1905–6, by which time new outlets had been found and China tea was practically driven from the British markets.

The World's Trade in 1900

Country.	Exports. lb.	Percentage of total trade	Country.	Consumption.[1] lb.	Percentage of total trade.
British India	176,300,000	30·0	United Kingdom	247,000,000	42·0
Ceylon	149,200,000	25·3	Australia	27,000,000	9·2
Java	16,000,000	2·7	New Zealand	5,000,000	
China	184,500,000	31·3	Canada	22,500,000	
Japan	41,000,000	6·9	United States	96,500,000	16·4
Formosa	20,000,000	3·4	Russia	100,000,000	17·0
Other countries	2,000,000	0·4	Continent of Europe (excluding Russia)	30,000,000	5·0
			Other countries	61,000,000	10·4
Total	589,000,000	100·0	Total	589,000,000	100·0

[1] *Consumption in the producing countries is not shown.*

During the early years of the present century the Indian tea industry passed through a very severe trial, and in the less favoured districts, especially in the Terai and Cachar, large areas of tea were temporarily abandoned. Many small concerns without sufficient capital were unable to carry on, but, as there was never any doubt regarding the ultimate stability and soundness of the industry, large joint-stock companies were formed to amalgamate a number of separate estates under one management. Up to 1906 practically no extensions were made; the area under

cultivation was, however, more fully developed and great improvements were made in estate management. The end of the crisis found the industry placed in a very sound position. Ceylon weathered the storms more successfully than India, as the planting industry was more compact and better organised, the average yield of tea per acre was at that period much greater in Ceylon than in India, and, owing to the favourable situation of Colombo as a port of call for steamers trading with different parts of the world, new markets were more readily found for the produce of the island. Since 1904 great interest has been taken in rubber planting in Ceylon, and about 270,000 acres have been planted, while the area under tea has remained stationary.

The industry had barely recovered from the depression brought about by over-production when extensions on a large scale were undertaken in nearly all the tea districts of India; 71,000 acres were planted between 1907 and 1913, and a further area of 69,000 acres in the next five years, of which over 50,000 acres were planted during the war. The new planting was made in the districts where the best yields are obtained, viz.: Assam, 46,000 acres; Dooars, 32,000 acres; and Southern India, 45,000 acres. Between 1907 and 1918 the planted area had been increased by 26 per cent., whereas the crop obtained in 1918 was 55 per cent. greater than that of 1907; the average yield of tea per mature acre had been raised from 470 lb. in 1907 to 609 lb. in 1918. If these large extensions had been confined to India alone, the present crisis in the tea trade would not have arisen. Unfortunately, however, for the general prosperity of the industry, planting on an extensive scale was simultaneously carried out both in Java and Sumatra. This new enterprise was largely financed with British capital, as the Dutch Government offered very favourable terms to anyone prepared to develop their waste lands.

In 1913 the tea industries of the world appeared to be in a prosperous condition, the large areas put out after 1907 had not all come into bearing, and the increase in the demand was absorbing all the teas produced in the British and Dutch Indies.

The World's Trade in 1913

Country.	Exports. lb.	Percentage of total trade.
British India	291,700,000	37·3
Ceylon	197,400,000	25·2
Java	65,000,000	8·3
China	166,500,000[1]	21·3
Japan	34,000,000	4·4
Formosa	24,000,000	3·0
Other countries	3,400,000	0·5
Total	782,000,000	100·0

Country.	Consumption.[2] lb.	Percentage of total trade.
United Kingdom	306,000,000	39·8
Australia	37,000,000	
New Zealand	8,000,000	
Canada	36,000,000	11·3
Other British countries	10,000,000	
United States	95,000,000	12·0
Russia	190,000,000	24·2
Holland	25,000,000	
Other countries of Europe	20,000,000	5·7
South and Central America	12,000,000	
Northern Africa	10,000,000	
Persia, Asia Minor	18,000,000	7·0
Other Asiatic countries	15,000,000	
Total	782,000,000	100·0

[1] *This figure does not include* 25,000,000 *lb. of tea imported from the British and Dutch Indies for the manufacture of brick tea, which was re-exported to Russia.*

[2] *Consumption in the producing countries is not shown.*

During the early years of the war, in 1915 and 1916, the Russian demand for black tea was very large, and consequently the crops produced during those years were absorbed. The trouble commenced with the Revolution of 1917, when the Russian demand gradually dwindled until it practically ceased; the shortage of tonnage and the submarine menace during 1917–18 also added to the difficulties of the situation. During this period Government took over control of the tea trade, rationed tea, and fixed a flat rate for its sale in the United Kingdom; at the same time two-thirds of the Indian and Ceylon crops for 1918 were bought ahead at an average price based on pre-war prices. This was a satisfactory arrangement for growers, from an immediate financial point of view, and it at the same time relieved them of the responsibility of marketing the bulk of their produce. In one respect it was, however, an unfortunate arrangement, as it did not limit the quantity of tea to be produced, and,

as a flat rate had been fixed for the sale of tea in the United Kingdom, there was no encouragement to the growers to make high-class teas; it paid them better, under the terms of their contract with Government, to supply medium teas in large quantities.

It is difficult to follow the movements of the trade during 1917 and 1918, or to ascertain whether stocks were accumulating. The annual production in India was 64,000,000 lb. greater than in 1913, the Dutch Indies were also producing more tea, and the Ceylon crops were maintained. On the other hand, owing to enforced restrictions, the consumption in the United Kingdom was much below the pre-war level, and there was little demand from Russia. Government was, however, purchasing largely to supply the requirements of the troops, and at the close of the war large stocks must have been held at the various military centres all over the world; during the two years in question, considerable quantities of tea must have been lost with the sinking of ships.

At the beginning of 1919 prices in London for all grades of tea were good, stocks in the United Kingdom were not excessive, but apparently no account was taken of stocks held in the producing countries. The tea trade had been disorganised by the war and by Government control, and, as no danger signals, pointing to over-production, were raised, the plantations in the British and Dutch Indies in 1919 produced tea to their full capacity. The production in these countries exceeded 700,000,000 lb., or nearly 150,000,000 lb. more than in 1913. This increase was made in spite of the loss of the Russian market, which had been taking nearly 100,000,000 lb. of plantation tea. The situation was relieved to some extent by increased consumption in the United Kingdom, and larger shipments to Australia and North America. Tea was accumulating in many places, but it was not until the middle of 1920, when abnormal stocks had accumulated in the United Kingdom, that the real situation was recognised. There was then a break in prices for all the lower grades, which have since been selling below the economic level.

The World's Trade in 1919

Country.	Exports. lb.	Percentage of total trade.
British India	371,500,000	43·2
Ceylon	208,000,000	24·2
Java	111,000,000	14·0
Sumatra	9,500,000	
China	92,000,000	10·8
Japan	40,000,000	4·6
Formosa	24,000,000	2·8
Other countries	3,000,000	0·4
Total	859,000,000	100·0

Country.	Consumption.[1] lb.	Percentage of total trade.
United Kingdom	388,000,000	45·1
Australia	46,000,000	11·8
New Zealand	9,000,000	
Canada	36,000,000	
Other British countries	10,000,000	
United States	108,000,000	12·5
Russia	15,000,000	1·7
Holland	55,000,000	8·1
Other countries of Europe	15,000,000	
South and Central America	10,000,000	6·2
Northern Africa	10,000,000	
Persia, etc.	18,000,000	
Other countries in Asia	15,000,000	
Balance	124,000,000	14·6
Total	859,000,000	100·0

[1] *Consumption in the producing countries is not shown.*

The most interesting features on the export side of the above statement are the increase in shipments from India and Java and the decline in the China trade as compared with 1913. On the other side, the consumption in the United Kingdom was 72,000,000 lb. greater than in 1913, and Australia, the United States and Holland all imported more, although it is not certain that the whole of these teas went into consumption. The Russian imports were on a limited scale, and obtained mostly from China. The actual consumption of tea in the world in 1919 was 100,000,000 lb. less than in 1913. In 1919, about 540,000,000 lb. of tea were consumed in the British Empire, including 50,000,000 lb. retained for use in India. The production of British-grown teas in the same year amounted to about 580,000,000 lb. In the United Kingdom, Canada, and New Zealand some protection is afforded to British-grown teas; in Australia, however, all teas are admitted free of duty. Java teas are now competing successfully with Ceylon teas in the Australian markets, and are also entering into consumption in considerable quantities in this country, in spite of the higher rate of duty imposed.

The following statement shows the quantities of tea from different countries entered for home consumption in the United Kingdom in 1919 and 1920.

Country.	1919.		1920.	
	Quantity.	Percentage of total.	Quantity.	Percentage of total.
	lb.		*lb.*	
India . . .	258,813,863	66·7	241,553,481	61·5
Ceylon . . .	106,400,008	27·2	112,060,713	28·5
China . . .	4,427,616	1·2	3,584,700	0·9
Java, etc. . .	18,824,046	4·9	35,624,863	9·1
Total . .	388,465,533	100·0	392,823,757	100·0

With effect from June 2, 1919, the rate of duty on British-grown teas was reduced to 10*d.* per lb., whereas the full rate of 1*s.* per lb. was levied on foreign teas. The increase in the consumption of teas from the Dutch Indies has, therefore, taken place in spite of the preferential duty. This is not a satisfactory feature of the trade, so far as it concerns the producers in India and Ceylon, as there were abnormal stocks of British-grown teas in this country in 1920, and exports of tea from India were being restricted on this account.

At the present time stocks of tea in the United Kingdom exceed 220,000,000 lb., notwithstanding the fact that shipments from India from April 1 to December 20, 1920, amounted to only 176,000,000 lb. against 269,000,000 lb. for the same period of 1919. It is evident, therefore, that a large proportion of the 1920 crop is still in India. The Indian crop of 1920, owing to climatic causes, was a short one; on the other hand, the consumption of tea in this country during 1920 was almost abnormal, and it can hardly be expected that this high rate of consumption can be maintained under the existing conditions of trade depression. The present situation is very serious for the Indian and Ceylon tea industries as only fine teas are selling at a profit, the prices obtained for medium and common teas having fallen far below the cost of production. Many estates, which produce mainly medium grade teas, are now in financial difficulties and will not be able to carry on unless either prices improve or relief in some form is provided to enable them to tide over the present crisis.

The tea industries of India and Ceylon have been considering the reduction of the crops for 1921 to 80 per cent. of the average crops between 1915 and 1919; they have also appealed to their respective Governments for assistance, and urged that the export duty on tea, recently imposed in both countries, should be removed. The question of providing employment for the large labour supply, which has been collected by the tea estates at great expense, is one of great importance. It is not desirable that this labour should be dispersed, for this would not only ruin the prospects of the industry for some years, but would also entail great hardships on the coolies and their families.

The present crisis is, in some respects, more serious than that which occurred in the nineties; prices for common and medium teas have now fallen to a lower level, while expenses have advanced by fully 30 per cent. In the nineties, moreover, India and Ceylon were rapidly taking over markets which had hitherto been supplied by China, whereas at the present time Java is competing with British-grown teas in those markets. There is no question regarding the soundness and ultimate prosperity of the tea industries of India and Ceylon; the immediate outlook for many estates is, however, very critical. An industry which supports at least 3,000,000 workers and their dependants in the two countries mentioned above is certainly deserving of sympathetic treatment by the local authorities. The most serious obstacle to the return of more healthy trade conditions is the great accumulation of stocks of common teas. In the absence of a demand from Russia, there appears to be little prospect, in the immediate future, of reducing the volume of these stocks, but unless this is effected, or the sales of tea regulated, there can be no recovery in prices for a long time. It is to the common interests of both the producer and the consumer that the tea industry should be placed on a sound basis.

PRESENT POSITION OF THE CAMPHOR INDUSTRY

Demand

Camphor has long been in great request in medicine, especially in China, where, however, ten times the price paid for ordinary camphor obtained from *Cinnamomum Camphora* is given for ngai, or *Blumea* camphor, and eighty times as much for barus, or *Dryobalanops* camphor. In India there is a very large demand for camphor, which is used especially in the lamps burnt in the ceremonies of *árta* and *árti.* This demand was formerly largely met by the importation of crude camphor from China, through Hong Kong, which was refined at Bombay ; of late years, however, there has been an increasing importation of refined camphor from Japan. Camphor has come to Europe almost entirely in the crude state, from China, Formosa or Japan, the process of refining being a Dutch secret at the close of the seventeenth century and afterwards a Venetian monopoly, but more recently carried out in England, Hamburg, Paris, New York and Philadelphia, as well as in Japan. Camphor was at one time employed in the manufacture of smokeless powder ; but by far the greatest impetus that the demand has ever received has been that for the manufacture of celluloid. In 1912 it was estimated that 70 per cent. of the world's consumption of camphor—then put at 11,000,000 pounds —was used for this purpose, the balance being employed for disinfecting and deodorising, and for medical purposes ; a more recent estimate puts the celluloid demand at 80 per cent. of the total. In addition to the extensive employment of celluloid and allied products, such as xylonite, for an immense variety of purposes, mostly, but not entirely, ornamental; the rapid increase of the cinematograph industry has led to a greatly enlarged demand for it as a material for the manufacture of films.

The chief importing countries of late years have been the United States, the original home of the celluloid industry, Germany and India. The amount of crude camphor imported into the United States exceeded

2,800,000 lb., in 1904, had risen to nearly 3,500,000 lb., in addition to over 1,000,000 lb. of refined camphor, in 1914; was over 5,500,000 lb., in addition to more than 3,000,000 lb. of the refined product, in 1916, and about the same in 1917; but fell in 1918 to 2,800,000 lb. of crude and 735,000 lb. of refined. Germany imported nearly 2,250,000 lb. of crude camphor from Japan and Formosa in 1904, and rather more than that amount from Formosa in 1911. The total import of camphor into India in 1911–12 exceeded 1,500,000 lb., and in 1915–16 was over 2,000,000 lb. In 1917–18 India imported 1,660,000 lb. of which 1,350,000 lb. came from Japan; but in 1918–19 the import fell to 784,000 lb., of which 428,000 lb. was from Japan. The total amount of camphor taken by the United Kingdom from Japan has fluctuated considerably during the last ten years, as is shown by the following table of its annual value; but since the outbreak of the war it has been much below that of the United States.

Value of export of camphor from Japan:

	To U.K. £	To U.S.A. £
1908	15,086	74,855
1909	91,178	84,444
1910	59,394	70,761
1911	60,691	61,128
1912	66,671	39,935
1913	14,109	44,458
1914	34,070	71,289
1915	28,975	90,899
1916	60,594	319,009
1917	24,625	249,125
1918	78,285	113,158

The total amount of camphor taken by Europe and the United States in 1914 is said to have been 12,000,000 lb.

Past and Present Sources of Supply

Before the war of 1895, which resulted in the transfer of Formosa from Chinese to Japanese rule, most of the camphor of commerce, though known as Chinese, was probably of Formosan origin. It was then shipped in square metal-lined chests, water having been added to it from the notion that it prevented evaporation. It fetched a lower price than the purer dry Japanese "tub camphor." The tree from which common camphor is

distilled (*Cinnamomum Camphora*, Nees and Eberm.) is native in Japan, Formosa and a considerable part of China from the Nan Shan range, Sechuen, Hupeh and Chekiang southward; but nowhere forms pure forest, and seems, except in Formosa, to occur generally in a very scattered manner.

China.—In China, the wood has been extensively used for the keels of junks, coffins and furniture, and in 1900 it was sold in Wuchow for firewood at six dollars a ton, but is said now to be too scarce in the accessible districts to be employed for such purposes. The Chinese export of camphor in 1891 (before the cession of Formosa) was 17,000 piculs (over 2,250,000 lb.), and, according to a Chinese authority, the province of Fukien alone had in 1905 more camphor trees than Formosa. On taking over Formosa, the Japanese found that the best supply of camphor was in the most inaccessible part of the island (which is rendered still more unapproachable by the presence of hostile head-hunting savages) and seem, therefore, to have endeavoured to meet the growing demand by exploiting the Chinese supply. According to the Chinese authority already quoted the whole province of Fukien was overrun, between 1903 and 1907, by Japanese employés, and "the Japanese saw that it was only by rapidly destroying the industry in Fukien that they could create a monopoly for themselves." The export of camphor from Foochow rose from 264 cwts. in 1902 to 13,535 cwts. (1,516,600 lb.) in 1906, and in the latter year there were twenty distilleries in Foochow. The Japanese, and afterwards the Provincial Government, attempted to monopolise the industry; but they were not altogether successful as the camphor-wood brought in rafts from the interior is invariably concealed to evade the duty. Although there was a law that five trees should be planted for every tree cut down, all available trees were cut and no planting took place. As an inevitable result the industry rapidly declined, as shown by the following table.

Total Chinese Exports of Camphor in Pounds

1907 .	3,433,937	1912 .	331,000	1915 .	181,735
1908 .	1,742,933	1913 .	248,700	1916 .	316,933
1911 .	448,133	1914 .	241,333	1917 .	472,933

The revival under the stimulus of rising prices which is here shown after 1915 came mainly from the province of Kiangsi, in which there are stated to be camphor forests and some undeveloped territory, especially in the south. A factory was established at Kiukiang, the river port of Kiangsi, in 1904; but no Chinese factory has yet adopted modern methods of distillation. Of the total export in 1916, of which about two-thirds came from Kiukiang, about 200,000 lb. went to Hong Kong, where, before the war, most of the trade was in the hands of German firms. In 1917 the United States took nearly as much as Hong Kong (about two-fifths each), and the bulk of the remainder went to Japan. In 1919 Kiukiang alone produced 332,266 lb., and a slight improvement in Fukien produced a yield of 56,533 lb. from that province in 1918.

Japan.—It is difficult to arrive at any precise estimate of the production and home consumption of camphor in Japan prior to the acquisition of Formosa; but the export, which had been over 6,577,000 lb. in 1889 and about 5,860,000 lb. in 1891, had fallen to 2,961,000 lb. in 1895. The exports returned after that date doubtless include some camphor grown in Formosa, as do the Chinese figures in the previous period; but Japan is credited with an export of over 5,500,000 lb. in 1901, which fell to little more than 3,000,000 lb. in 1905. In 1907–8, 1,618 families were engaged in camphor production in Japan, and the production of crude camphor was 987,922 lb. In 1910–11, 2,615 families were employed, and the production was 1,394,896 lb. In 1915–16, 4,239 families produced the maximum amount of 2,117,878 lb. In the following year 4,329 families only produced 2,074,113 lb., and in 1917–18 only 3,274 families were engaged in the industry, and the production fell to less than 1,300,000 lb. Whilst the Chinese production has been estimated at four times the amount exported, that of Japan was, until the last few years, probably nearly all exported.

Formosa.—It is probable that, at least from the early years of the present century, the greater part of the world's supply of camphor has been of Formosan origin.

In 1895 the export from that island was 6,927,000 lb. There are no refineries in Formosa, and up to that date, nearly all the world's supply of camphor was shipped to Europe in a crude state and refined there. Distillation was afterwards begun at Kobé and Osaka, and is now concentrated in the hands of two companies. In 1910 the number of workers in the camphor industry in Formosa was 24,800. The total export from the island in 1913 was over 7,860,000 lb., more than half of which went to the United States. The following table shows the division of the exports for the years 1915–19, with the balance retained in Japan, and illustrates the falling off in the supply since 1916–17, which is, perhaps, the most serious feature in the present position of the trade.

Production and Export of Formosan Camphor

	Production.	Export to United States.	Export to Europe.	Balance to Japan.
	lb.	*lb.*	*lb.*	*lb.*
1915–16 . .	10,389,521	4,211,766	1,798,277	4,379,478
1916–17 . .	11,506,447	6,525,489	1,726,997	3,253,961
1917–18 . .	7,945,890	4,129,027	1,045,345	2,771,518
1918–19 . .	6,137,732	2,055,188	913,021	3,169,523

The total world's output of crude camphor would seem to have risen during the first decade of the century from 7,000,000 to 10,000,000 lb., to have culminated in over 17,000,000 lb. in 1916, and to have declined to 12,000,000 lb. in 1917, and to about 10,000,000 lb. in 1918.

The Future Supply

Japanese Supply.—All the natural camphor of commerce has hitherto been prepared by the destructive distillation of the wood of mature trees, and the growing demand has been mainly met by what has been called the "exploitation" of new and less accessible areas, though it is claimed that improved methods of distillation have increased the Japanese yield by 10 per cent. In Formosa the destruction of trees has been reckless, the distillation of the branches, twigs and roots being entirely neglected; and there is at present a shortage of labour available for the collection of the wood, partly owing to the higher wages obtainable in other industries, such as

sugar-cane cultivation, which are carried on in the lowlands secure from the attacks of the savages. Recent increase in the rate of pay to the workers failed to bring in any increased supply. A military force is constantly engaged in protecting the camphor collectors on the savage frontier, and upwards of 100 persons per annum are reported to be killed in this region. The Japanese Monopoly Board are stated to have planted 3,000,000 trees between 1900 and 1906, and 11,000,000 in the three following years, and to have resolved from 1913 to plant 3,000 acres with camphor annually for twelve years. About 1,270 trees are planted to the acre. After five years' experimenting it was stated in 1912 that leaf-distillation was to be begun on a practical scale, and it was estimated that 6,500,000 lb. of camphor would be produced annually from these plantations; but in 1918 it was said that the hopes of obtaining camphor from the leaves "have not materialised," and that the camphor from young trees is unsatisfactory. The plantations were, however, evidently made with a view to the possible continuance of wood-distillation; but, whilst in 1917 it was considered that the trees could not be utilised for thirty years, in 1919 the Monopoly Board announced their expectation that, at an annual output of 5,000,000 kin (6,615,000 lb.), the wild trees of Formosa will last for 10–15 years, by which time the plantations can begin to be cut. This will, however, mean the cutting of trees less then 35 years old, whilst the wood of the stem is not considered truly mature, *i.e.* at its highest yield, till the trees are 60 years old. Meanwhile the Board anticipated a yield of 4,000,000 kin (5,291,000 lb.) for 1919–20, and a return to the normal yield of 5,000,000 to 6,000,000 kin (6,615,000 to 7,938,000 lb.) for the next year. Whilst it is obvious that this yield, even if realised, will not meet the world's demand for camphor, the restrictions upon exports imposed by the Japanese Government will permit only a very small proportion of the supply to enter foreign commerce. The government monopoly of crude camphor established in Formosa in 1899 was extended to Japan in 1903, and the latter country is rapidly becoming a manufacturing area rather than a region of production and export of the

raw material, a trend which has been accentuated since the war broke out. In 1918 the Board allotted 60,000 piculs to the two Japanese refining companies which now control the industry, and 12,000 piculs to the native celluloid manufacturers, making a total of 72,000 piculs, or 9,600,000 lb. of crude camphor for home manufacture: and in May 1920 all export of crude camphor was prohibited, a limited amount of refined camphor being allowed to foreign refiners at a discount of 3 per cent. below the market price.

Chinese Supplies.—The threatened monopoly not only of the camphor-refining, but also of the celluloid industry by Japan has naturally stimulated the search for other sources of supply of camphor or for substitutes for it for the manufacture of celluloid. American buyers are looking to China for an immediate addition to the supply. In the Shan States of South-West Yunnan there are stated to be an immense number of camphor-trees only awaiting transport facilities for their exploitation. In Fukien the remaining trees are scattered, and mostly in more or less inaccessible mountainous districts, and there are neither railways nor even good roads, the camphor being brought by porters to the Min River, and by native boats to Foochow. Labour is cheap; but many of the Chinese, having lost money in the trade, are unwilling to re-enter it. The Chinese authority already quoted recommends that an American Syndicate should start operations in South Hunan and South Kiangsi, establishing distilleries on modern lines, cutting in a conservative manner, and encouraging planting by demonstration plantations, lectures, pamphlets, and the free distribution of seed and seedlings; and should afterwards extend their action into Kweichow, Kwangtung and Kwangsi. Experimental production from wild and planted trees is being carried out in the island of Hainan, and the native camphor-oil, which in China usually contains 60 per cent. of camphor, is being bought up.

Planting in the United States.—The camphor-tree was introduced into Florida between 1870 and 1875, but the production of camphor did not begin until 1904. The Celluloid Company now have 3,000 acres planted at Sat-

suma, and the Arlington Company 12,000 acres at Waller, planted since 1914; and planting has also been carried out in Texas and in the San Joaquin Valley, California. The trees do well in poor sandy soil, being sown thickly at first, and transplanted when a year old into rows 15–16 ft. apart, and 3½–4 ft. apart in the rows. The leaves are cut four years after transplanting, new growth rapidly replacing the portion pruned, so that two prunings may become possible within the year. The rows are ultimately trimmed into V-shaped hedges 7–8 ft. high, and with a width at the base equal to their height; and the yield of flush, estimated in 1910 at 8 tons per acre per annum, giving from 175 to 200 lb. of camphor, is now reckoned on the more cautious estimate of 5 tons yielding from 125 to 150 lb. of camphor. The United States Agricultural Department have a special station for the study of camphor at Orange City, and a trimming machine has been designed which prunes 6 acres per day. It has been found that the young leaves contain more camphor than the one- or two-year-old wood, so that no severe pruning is desirable; but, if the leaves are cut once or twice a year, it seems improbable that, as seems to be expected in Florida, the mature wood in later years can contain much camphor. Fallen leaves give a good percentage of oil and camphor, and it appears economical to air-dry the leaves before distillation, but rain or direct sun on the flush reduces the camphor-content. Though there are trees two hundred years old at Tokyo, where there are 70 or 80 nights of frost in the winter with temperatures falling as low as 16° F. or even 12° F., successful camphor cultivation seems to demand generally a temperature not falling below 20° F. and a rainfall of not less than 50 inches. There being every prospect of successful cultivation in the Philippines, the Government have granted the control of a large area of suitable land there to an American company.

Cultivation in other non-British Countries.—In addition to the countries in which it is indigenous and to United States territory, various other countries within approximately corresponding latitudes have grown the camphor-tree more or less successfully. The imports into the

Straits Settlements, coming mostly from the east coast of Sumatra to Singapore, and mostly re-exported to Calcutta or other Indian ports, increased from 51,466 lb. in 1908 to 525,033 lb. in 1915, but declined in the four following years to 136,400 lb. in 1919.

In Madagascar the tree has been naturalised, and its wood was largely used for building more than fifty years ago. It also grows well in the Canaries, and in Buenos Aires. In Algeria its cultivation has been begun; but here, as it is to be feared elsewhere, there has been some confusion between the true species and the less camphoraceous *Cinnamomum glanduliferum*. In Italy, on the shores of Lago Maggiore, a tree has reached 90 ft. in height and a foot in diameter within eight years from the time of sowing, a height rarely reached in a century, and a diameter usually requiring 25 years' growth.

Cultivation in the British Empire.—In Burma, where the species does not appear to be known in a wild state, it grows well in Upper Chindwin, Myitkyina, Bhamo and the Southern Shan States, where there are plantations up to altitudes of 3,000 ft.; but plantations at 4,000 and 6,000 ft. have failed. It is reported that camphor is now being made at Yatsank in the Southern Shan States, where there is a plantation of 650 acres.

The tree does well at Ootacamund in the Nilgiris, at an altitude of 7,300 ft., and has also grown well at Dehra Dun, though the yield of oil obtained from the latter locality was very small.

In the Federated Malay States experimental planting began at Batu Tiga, Selangor, in 1904, and the growth during the early years was equal to that in Japan. The tree was found to be liable to the attacks of termites, the larva of the Atlas moth, *Fomes*, thread-blight, brown-root, and other insect and fungoid pests which attack rubber; but it was possible to begin pruning in the third year, an acre of 700 trees yielding about 5 tons of flush three times a year, and the leaves, when air-dried, giving from 1·1 to 2·6 per cent. of crude camphor. Assuming a yield of 1 per cent., 10,000 lb. of flush are required for 100 lb. of crude camphor, as against 15,400 lb. with a

yield of 0·65 per cent. from prunings of trees under three years of age, so that a total of 60 lb. of camphor from one pruning of an acre, or 180 lb. per annum, should be obtained. The cost of collection, distillation and shipping is estimated at 63*s*. per 100 lb.

In Ceylon, camphor cultivation was begun about 1893 by Nock at the Hakgala Gardens, six miles from Nuwara-Eliya, at an altitude of 5,600 ft. Seed obtained from the Yokohama Seed Nursery was found to germinate irregularly ; but root-cuttings were distributed to planters at altitudes of from 250 to 6,000 ft. Ceylon being nearer the Equator than the natural range of the species, it was found not to flourish below 2,000 ft., but did well between 3,000 and 5,000 ft. even on wind-blown hill-crests, forming an effective wind-screen for tea. Lime and potash were found to be necessary in the soil. The trees were coppiced to a height of 4 or 5 ft., and were found to yield 14 lb. of flush per annum each, giving from 27 to 34 per cent. of camphor-oil, and 0·75 to 1 per cent. of camphor, which, with the trees 4 ft. apart in rows 8 ft. apart, *i.e.* 1,360 to the acre, should give 143–190 lb. of camphor per acre. In 1910 Messrs. Bamber and Willis reported the success of camphor cultivation in Ceylon, the trees when planted in hedges running across the direction of prevailing wind, where the rainfall is not less than 90 in. and the soil is a sandy loam, reaching 18–20 ft. in five years. The seed, which ripens in Japan during October and November, does not keep well, but may be stored in moist charcoal until May or June, and should be soaked for a day or two before being sown.

In Mauritius a species of *Cinnamomum* has grown well, but yields an oil very different from true camphor-oil, containing cineole but no safrole and little camphor (see this BULLETIN, 1916, **14**, 580).

Lommel at Amani in Tanganyika obtained a higher yield from the leaves of trees grown there than that usual in Japan.

Experiments in South Africa suggest that camphor might be profitably cultivated in some of the warmer and moister parts of the territory of the Union.

In the West Indies at least three distinct forms appear to be in cultivation. A tree at St. Vincent, upwards of 100 years old, which has never been known to flower, has been identified at Kew as *Cinnamomum Camphora* var. *glaucescens*, yields oil, but not any solid camphor from its wood. Another equally unproductive variety grown in Trinidad and Dominica is distinguished by its reddish shoots and leaf-stalks and its ovate leaves, which smell of turpentine when they are crushed; whilst there are also trees in these two islands and in Jamaica the leaves of which give a normal yield of 1 per cent. or more of camphor. Obviously the inferior varieties should not be allowed to hybridise with the true variety, and should as far as possible be eliminated.

In Queensland, *Cinnamomum Camphora* is commonly grown, and a native species, *C. Oliveri*, is stated to contain camphor, but requires further examination; and in the Young district of New South Wales a fifteen-year-old tree gave 1·02 per cent. from its fresh leaves, a result comparing favourably with those obtained in Florida and elsewhere. It is suggested that the leaves might advantageously be distilled for the crude product in the bush with similar apparatus to that employed for the Eucalypts.

It is thus clear that the camphor-tree can be successfully grown in many parts of the Empire, and, if care be taken to secure the true form, a small but constant yield of camphor can be obtained by the distillation of the leaves which, at prices considerably below those now general, will be amply remunerative. As there is less camphor in the young wood than in the leaves, severe pruning is not desirable, and, as already mentioned, it does not seem probable, though some American growers appear to expect it, that, after clipping and distilling the leaves for years, there will be much camphor in the stem when the old trees are felled. Giving a return after three or four years, the crop is far less speculative in character than if planted for wood-distillation after the lapse of from fifteen to sixty years; but the demand for camphor is largely dependent on the wants of the manufacturer of transparent celluloid, and its price on that of Formosan

labour. As it appears possible to manufacture camphor in Formosa at an exportable price of sixpence per lb., that is the necessary limit to the cost of its production elsewhere, whether from the same or any other plant, or by synthesis from turpentine.

Synthetic Camphor

A number of methods have been devised for making synthetic camphor, but hitherto it has not been profitable to make it on a commercial scale in competition with the natural product. The so-called "artificial camphor," which differs widely from true camphor, consists of pinene hydrochloride, which is prepared by treating turpentine-oil with dry hydrogen chloride. True synthetic camphor may be made by preparing borneol or isoborneol from pinene hydrochloride or hydrobromide, and subsequently oxidising it. The synthetically prepared product resembles true camphor in most respects, but it is usually optically inactive, and often contains small quantities of borneol and other substances as impurities.

The American camphor-refiners are seriously considering the desirability of developing the manufacture of synthetic camphor. The only synthetic camphor ever successfully marketed in the United States was that made in Germany by the Schering Chemical Works in 1908, the sale of which was then crushed by the rise in the price of turpentine, and the fall in that of Japanese camphor. In 1907 synthetic camphor was sold in London at 2*s.* 3*d.* to 2*s.* 6*d.* per lb., when American turpentine was fluctuating between 37*s.* 6*d.* and 73*s.* per cwt. The quantity of turpentine required is stated to be 36 gallons for 98 lb. of camphor, and the present price of turpentine in the United Kingdom is about 46*s.* per cwt., which, at 8·7 lb. to the gallon, implies a cost of about 1*s.* 4*d.* per lb. of camphor for turpentine alone. It may, of course, be cheaper to manufacture synthetic camphor in the United States than in the United Kingdom or Germany, as the first-mentioned country has the cheapest source of turpentine, and an import duty of 6 cents per lb. on refined and synthetic camphor.

General Conclusions

The effect of the Japanese monopoly has been to encourage the production of natural camphor in various countries, and has stimulated the efforts to solve the problem of the profitable manufacture of synthetic camphor. The camphor difficulty is not merely a question of the high price of Japanese camphor, but the almost complete absence of this product from the free markets of the world. The production of camphor from leaves in Florida will alleviate the position to some extent as far as the American manufacturer is concerned, but strenuous efforts should be made to obtain supplies within the British Empire, by the cultivation of the camphor-tree in those countries suitable for its growth, and by undertaking the manufacture of synthetic camphor in the United Kingdom.

NOTES

Lead Ores: Imperial Institute Monograph.—In the series of *Imperial Institute Monographs on Mineral Resources*, a new volume on Lead Ores by Mr. J. C. Hall, M.Inst.M.M., F.G.S., has been published by Mr. John Murray, price 6*s*.

The book contains 127 pages, and is divided into three chapters, the first of which deals with lead-bearing minerals; the genesis and mode of occurrence of lead ores; the lead content, concentration, valuation and smelting of lead ores; the refining, marketing, properties and utilisation of lead, including a description of lead alloys and the lead pigments, the various processes used in the manufacture of the latter being briefly described; and concludes with statistics of the production and consumption of lead.

The two remaining chapters are devoted to the sources of supply of lead ores. The second chapter deals with those of the British Empire, and includes descriptions of the lead-ore deposits of the United Kingdom; of Bawdwin in Upper Burma; of the Slocan district, British Columbia; of Broken Hill, New South Wales; and of the Read-Rosebery and Zeehan districts of Tasmania.

The third chapter is confined to foreign countries, and describes the principal lead-ore deposits of Austria,

Belgium, Czecho-Slovakia, France, Germany, Greece, Hungary, Italy, Spain, Upper Silesia, Yugo-Slavia, and other countries in Europe; of Asia Minor, China, Indo-China and Japan in Asia; and of Mexico, the United States, etc., in America.

The work contains many statistical tables, a map showing the principal occurrences of lead ore in the world, an appendix on lead-poisoning and a bibliography.

Chromium Ore: Imperial Institute Monograph.—A monograph on Chromium Ore by Mr. W. G. Rumbold, has been published by Mr. John Murray in the series of *Imperial Institute Monographs on Mineral Resources*, price 3*s*. 6*d*.

The book, of 58 pages, is divided into three chapters, in the first of which are given a list of chromium minerals, with analyses of chromite from various parts of the world; the valuation and prices of chromite; the mining and concentration of the ore; and a description of the principal uses of chromite in the steel, chemical and other industries.

The second chapter deals with the sources of supply of chromite within the British Empire, and includes descriptions of the deposits of Baluchistan, Mysore and Singhbhum, India; Selukwe, Southern Rhodesia; the Lydenburg and Rustenberg districts of the Transvaal; Coleraine, Thetford and Black Lake, Quebec; Newfoundland; and Australia.

The third chapter is devoted to foreign countries, and contains descriptions of the principal chromite deposits of Lower Silesia; Volo and Pharsala in Greece; the Urals, Asia Minor, Japan, New Caledonia, Cuba and the United States. A map of the world showing the positions of the deposits referred to in the text is given, and a bibliography is appended.

The book contains numerous statistical tables, and should prove useful to all interested in the chromite industry.

Bamboo Areas in India.—In the article on "The Utilisation of Bamboo for Paper-making," published in this BULLETIN (1920, **18**, 403), an account was given of the occurrence of bamboos in certain areas in India. In the *Indian Forester* (1920, **46**, 603), Mr. R. S. Pearson, the Forest Economist, gives details of some eighteen additional areas in which bamboo may be worked for paper-pulp. He also alludes to two other areas already leased. The first area described is that of Bhamo in Upper Burma, reported on by Mr. Cubitt, Deputy Conservator, in 1910, a factory for which might be established at Katha, Tagaung or Mandalay. Labour, which

is expensive in Burma, was stated by Mr. Cubitt to cost Rs. 15 per month, but Mr. Pearson states that it would now probably be double this price. Allowing for such increase, he believes that air-dried bamboo could be landed at the factory for Rs. 15 per ton. The species at Bhamo are *Dendrocalamus membranaceus* ("wagé"), *D. Hamiltonii* ("wabomyetsangyè"), and *Cephalostachyum pergracile* ("tinwa"), "of which large quantities can be extracted annually without either detriment to the forest or an appreciable increase in price."

Eleven sub-areas in the Arakan Division, partly described by Mr. Pearson in a previous report, have recently been partially inspected by him in conjunction with Mr. Walker, the Divisional Forest Officer. These districts, more or less in proximity to Akyab, are "sufficient to support several pulp-mills." The prevalent bamboo is *Melocanna bambusoides*, or "kayin," known elsewhere as "muli," a thin-walled species, which is easy to cut and dries quickly. As it flowered in 1911–13, and does so only once in thirty to thirty-five years, the supply is secure for many years (cf. this BULLETIN, 1920, **18**, 401). This species does not form clumps, but sends up single culms from its rhizomes, forming dense pure growths, of which an illustration is given in the article. The bamboos cover a series of parallel hill-ranges, about 300 feet above sea-level, their dense growth originating in the native system of "taungya" cultivation, which is apparently identical with the well-known chena system of Ceylon, and in the course of which large numbers of the bamboos are already habitually cut by the natives. Of these eleven areas, that of the Seik Chaung drainage, containing 380 square miles, is stated to be probably the best in the Division, since a fine waterfall above the village of Ponnyaleik, sixty miles above Akyab, would supply abundance of fresh water, and possibly power, in a region where most of the rivers are tidal. A rotation of seven years has been fixed for *Melocanna*, at which age its culms are from 20 to 35 feet high. Mr. Raitt's experiments showed that this species, containing much less pectose and more lignin than the larger and more thick-walled kinds, requires a pulping treatment different from that used for the latter.

Areas in Peninsular India are described, which comprise one in Chota Nagpur, three in Assam, one in the Surat Division of Bombay, and one in the Central Provinces. The first-mentioned includes over fifty square miles in the Kundrugutu block of the Porahat Forest near Singhbhum. It is densely stocked with *Dendrocalamus strictus*, in addition to sabai grass (*Ischæmum angustifolium*). This

area is only twenty miles from the Bengal-Nagpur Railway, and little more than 200 miles from Calcutta: owing to the recent discovery of enormous deposits of iron and other valuable ores, the district is the future "Black Country" of India; and, though one of the chief recruiting grounds for the Assam tea-gardens, has an abundant supply of cheap labour. Three and a half annas is the present rate of daily wages for men. The area is leased to a Calcutta firm for three years.

In the Borak and Kata Khal catchment areas of the Cachar Division of Assam are numerous partially examined bamboo areas, chiefly "old jhums," or areas over which shifting cultivation has taken place, in evergreen forest, with an average rainfall of 120 inches per annum. The prevalent bamboos are "muli" (*Melocanna*) and the slightly larger but lighter "dollu" (*Teinostachyum Dullooa*): no account of the suitability of the latter for paper-pulp has yet been published. The aggregate bamboo area is estimated as a minimum of 164,000 acres with 23·5 tons per acre, or a gross yield of 3,854,000 tons, which, on a seven-year rotation, would give 570,585 tons per annum, far more than sufficient for a single large factory. Badarpur, on the Borak River, a tributary of the Brahmaputra, and on the Assam-Bengal Railway, is indicated as the most suitable site for the factory, streams with channels deep enough for rafts of over 1,000 bamboos being available throughout the year. Labour is very scarce and indifferent, chiefly Mohammedans from Sylhet, costing 8 annas a day, so that the cost per ton of dry muli at the factory works out at Rs. 8.5.8, and that of dollu at Rs. 10.13.7. Limestone is available from the Khasia Hills, and firewood is plentiful; but coal cost Rs. 14 per ton at Badarpur before the war. These areas lie south of the Cachar Hills, and Mr. Pearson suggests that they should be worked in advance of the bamboo areas in the Langting forests north of those hills, which are unhealthy, remote from any village or source of labour supply, and have a long lead to any possible factory site.

In the western half of the Dangs of Surat it is estimated that there are 35 million culms of bamboo (*Dendrocalamus strictus*), which, on a five-year cutting rotation, only half of each clump being cut, would give 14,000 tons of dry material, or 5,600 tons of pulp per annum. Owing to a large and growing local demand for bamboos, a safer estimate would be 8,000 tons of raw material, or 3,200 tons of pulp. Chikar, on the Khapri River, is suggested as the factory site, with an average lead from the forest of about ten miles, and a cost for collection and delivery at the

factory of Rs. 8.12.0 per ton of bamboos. Firewood is obtainable, and limestone costs about Rs. 25 per ton.

In the Hoshangabad Division of the Central Provinces it is proposed to manufacture pulp from bamboo and sabai grass, the latter being at present exported from this district to the Poona mills. It is estimated that 2,000 tons of sabai and 4,000 tons of *Dendrocalamus strictus* are available annually, and that Bagra, on the Tawa River and the Bombay-Jubbulpore Railway, is the best site for the factory, which should have an annual outturn of 2,500 tons of air-dried pulp. The cost of fuel, chemicals, labour, etc., is approximately the same for bamboo and for sabai. Firewood being Rs. 5 a ton at Bagra, and about three tons of wood being equal to one ton of coal, which costs Rs. 14 a ton, the ton and a half of coal (or equivalent wood) requisite for a ton of pulp may be estimated at Rs. 22½, whilst chemicals would cost Rs. 56, labour Rs. 10 and fixed charges Rs. 20 per ton of pulp. The 2·7 tons of sabai needed for a ton of pulp would cost Rs. 70, the 2·2 tons of bamboo, Rs. 26½. This brings the total cost of sabai pulp to Rs. 178½, and that of bamboo to Rs. 135 per ton, while it is anticipated that imported sulphite pulp will not again be available at less than Rs. 195 per ton. A pulp of one-third sabai and two-thirds bamboo, which would be distinctly superior to imported sulphite spruce pulp, could thus be manufactured at Rs. 149½, *i.e.* 45½ rupees less than the estimated post-war rate for imported sulphite wood pulp.

Papyrus in Zululand.—In this BULLETIN (1916, **14**, 165) reference was made to investigations at the Imperial Institute on Zululand papyrus, and subsequently (1918, **16**, 578) to the grant of a concession of certain Crown Lands in Zululand to the Walmer Papyrus Company, Ltd., for the extraction of papyrus, and to the proposed erection of a mill for the conversion of the papyrus into paper-pulp for export. A summary was also given of a report by Messrs. Cross and Bevan on the value and possibilities of the papyrus for pulp and paper manufacture. Recently Mr. E. Fred. Heyerdahl, a Norwegian engineer, has surveyed the concession and advised the Company on the equipment of the mill and the methods of manufacture. The following notes are compiled from Mr. Heyerdahl's report.

The Papyrus Field.—The concession is about eighty miles long, varies from ten to fifteen miles in width, and extends from the river Umhlatuzi in Natal to the northern end of the St. Lucia Lake in Zululand. The greater part of the area is covered with papyrus which grows in swamps

and remains green throughout the year. The roots of the plants form a thick network on which rests a muddy layer of decayed papyrus-stem, whilst beneath it there is water varying in depth from 6 in. to 3 or 4 feet, according to the season. The papyrus fields thus consist of an enormous floating mass of plants, which is strong enough to carry machinery for cutting and for transporting the stems. The roots branch from the network, and, passing through the water, enter the clay beneath. In this clay roots are sometimes found to a depth of 10–12 feet. The stems grow to a height of 12–14 feet, and, although they constitute an annual growth, the continual shooting forth of new stems keeps the field green all the year round. The plants form so dense a jungle that it is impossible to walk through it without cutting a path. The vast fields are interrupted by a number of lagoons of a depth of 3–6 feet, which facilitate the transport of the material.

Harvesting.—On commencing to harvest a papyrus area an opening, about 3 yards wide, is cut across the field at a central point in which the main transport line can be laid. From this opening a belt, 100 yards wide, is cut in a direction at right angles to the main transport line, and a transportable branch line is laid down as the cutting proceeds. The cut and air-dried papyrus is conveyed in bundles to the branch line, the distance it has to be carried being thus reduced to about 50 yards as a maximum. As soon as the first belt of 100 yards has been cut and collected, an advance is made on the main line, and a further belt of 100 yards is cut, the branch line being transferred to the centre of this new belt. In this way the work is continued until the papyrus from the whole field has been harvested.

This method of harvesting can be varied according to the condition and situation of the fields. When the field is contiguous to a lagoon the main transport line is not employed, as the lagoon serves the purpose. In this case 100-yard belts are cut directly out from the banks of the lagoon, and the branch line is placed in the centre of each in turn.

The papyrus, after being cut, is dried in the fields for about three weeks before being collected. It is then gathered into bundles, which are carried to the branch line and loaded on trolleys, each of which can take a load of 1–2 tons, and the trolleys are drawn to the mill by motor-power.

When a lagoon serves as the main line of transport the dried papyrus is loaded directly on to pontoons capable of carrying 1–1½ tons each, which are driven into the field

on trolleys. The loaded trolley is driven to the lagoon, and the pontoon is floated off by a slip arrangement and taken by motor-tugs to the mill, where by a similar slip arrangement it is passed to the chipping machinery.

The green papyrus contains about 80 per cent. of moisture, but, after drying in the field, this is reduced to about 30 per cent., which has been found to represent the best condition for satisfactory working in the mill.

Yields.—It is estimated that the total area of the papyrus fields on the concession is about 800 square miles (or 510,000 acres). During April to July 1920 an approximation was made of the possible output per acre, and the cost of harvesting. This was effected by cutting and collecting about 500 tons of papyrus from different fields. It was found that one acre yields about 20 tons of green papyrus, which furnish about two tons of pulp, and hence the total area of 510,000 acres would afford more than one million tons of pulp per annum. Some of the fields are so situated that the cost of transporting the papyrus stems to the factories would be too great for profitable working. Assuming that such fields would amount to 50 per cent. of the whole, there would still be sufficient papyrus available for an annual production of 500,000 tons of pulp. It is estimated that the cost of harvesting the papyrus and transporting it to the mills, which would be erected at a number of suitable points, would not exceed 35*s.* per ton of pulp.

Manufacture.—The first mill erected by the Walmer Papyrus Company is at Umfolosi by the Engwisa Lagoon. It is close to the papyrus fields, and is connected with the railway to Durban by a transport line of 2 ft. 6 in. gauge, and 5 miles long. The mill is equipped for the production of "quarter stuff," which can be converted into a high class pulp by treatment with very dilute alkali and yields about 60 to 70 per cent. of bleached pulp. Trials carried out at this mill have shown that, on account of the bulky nature of the papyrus, special treatment must be employed before introducing it into the digesters. The air-dried stems must first be crushed, and then cut into small pieces or chips about $\frac{7}{8}$ to 1 inch long. This treatment has the following advantages. The chips can be easily transported to the storage bins over the digesters; the digesters can be rapidly charged, and the quantity which can be introduced is greatly increased. Moreover, the chipping enables the soda solution to penetrate the material readily and evenly during digestion, and the period of boiling is thus diminished. By using a solution containing a quantity of soda (Na_2O) amounting to ap-

proximately 10 per cent. of the weight of the air-dried material and employing a pressure of 40 to 50 lb. and forced circulation, the boiling can be completed in about three hours.

Colombian "Pita" Fibre.—In this BULLETIN (1918, **16**, 289) an account has been given of the results obtained at the Imperial Institute in the investigation of the "pita" fibre of Colombia. An illustrated article on this product has now been contributed by Mr. M. T. Dawe, F.L.S., to *Tropical Life* (1920, **16**, 182; 1921, **17**, 2).

The term "pita" is used very widely in Central and South America, and is applied to several fibre plants (including Sisal hemp) and also to string. The Colombian "pita" is a plant of the natural order *Bromeliaceae*, and is a species of Ananas closely allied to the pineapple. The plant has hitherto been regarded as *Ananas macrodontes*, but the examination at Kew of botanical specimens collected by Mr. Dawe in Colombia has proved it to be distinct from this species. Further material is being obtained with the object of definitely establishing the identity.

In appearance, pita resembles a very large pineapple plant. When mature it bears 20 to 40 leaves, which reach a height of 10 feet or more, and are about 4 inches wide at the middle. The plant reproduces itself abundantly by means of suckers which arise from underground stolons and grow so profusely as to cover the land to the exclusion of other forms of vegetation, except palms and other trees. Pita occurs as an undergrowth in the shade of forest trees, and forms extensive, dense, impenetrable areas, known as "pitales." It grows well on light sandy soil, but cannot thrive on wet land. Although the plant is generally met with in the shade of tropical forests, it is capable of growth on open land. It is found in Colombia at various places, ranging in altitude from sea-level to 3,000 feet.

The natives extract the fibre by holding the leaf with the foot on a flat, wooden block and scraping away the non-fibrous matter by means of a stick. This method is slow and wasteful, and would be impracticable on a large scale. The fibre is used locally for making fishing nets and thread for various purposes. In commerce, pita fibre would compete with Sisal hemp for the manufacture of rope and twine, but it is considered to be superior to Sisal hemp in strength, fineness and durability.

It has been estimated that in the Chiriguana forests the "pitales" contain from 5,000 to 8,000 plants per acre. Each plant yields thirty leaves annually in two cuttings, so that an acre containing 5,000 plants would furnish

150,000 leaves per annum, weighing about 102,000 lb. Extraction of the fibre from the leaves by the primitive native method yields 2 lb. of fibre per 100 leaves (weighing about 68 lb.), but in the process nearly 40 per cent. of the fibre is wasted, the actual quantity of fibre in the leaf being about 5 per cent. If by mechanical extraction a yield of 3 per cent. could be obtained, it is evident that the production per acre would be 3,060 lb. or about 1¼ tons of dry fibre.

It is claimed that the harvesting of fibre from the natural "pitales" possesses certain advantages over the cultivation of Sisal agaves in plantations. The clearing and planting of the land are avoided, and the waiting period of 3 to 4 years until the plants are ready to cut and the subsequent replanting are obviated. Moreover, capital would not be locked up as in the case of plantation industries, but immediate returns would be obtainable. There is, however, one great difficulty in this connection, namely, that no machine is yet available for the successful extraction of the fibre from the leaves. Some progress has been made in devising such a machine, and it is hoped that ere long this obstacle to the commercial production of pita fibre will be removed.

The Cultivation of Wheat and Barley in Mesopotamia.—In an article on "The Future of Wheat Production, with Special Reference to the Empire," published in this BULLETIN last year, attention was drawn to the great possibilities of Mesopotamia as a source of cereal supplies (1919, **17**, 231). The wheat and barley at present grown are of very mixed kinds, and in view of the prospects of a large export trade developing under settled rule, an enquiry has been made as to the different varieties cultivated in order to select from them the most suitable kinds for growing on a large scale. The results so far obtained are given in "A note on the Wheats and Barleys of Mesopotamia, together with Observations of Local Conditions," by C. R. Wimshurst, B.Sc., issued by the Agricultural Directorate, Mesopotamia (Superintendent, Government Press, Basra, 1920).

A botanical survey of the wheats grown on the Euphrates from Hillah to Fellujah was made by Lt.-Col. Graham in 1918, and twenty-six distinct types were collected. Eighty-seven lines, each sown from a single ear, were sown on the Base Dairy Farm, Baghdad, and, of these, twenty-five "split," indicating their hybrid origin. Five of the lines showed desirable characters in being early maturing and resistant to rust, whilst three others con-

tained rust-resistant strains ; all these were grown in bulk in 1919. Ears from the varying types into which the hybrid wheats split were also sown. Rust, due to *Puccinia graminis* and *P. glumarum*, often does serious damage, and the production of rust-resistant varieties is of paramount importance. The epidemics of rust are usually late in their incidence, and early maturing varieties therefore are most likely to withstand an attack. Although the selection of local varieties is being continued, Mr. Wimshurst considers that an exportable wheat can probably be placed in the hands of cultivators more quickly by introducing and propagating on seed-farms types well known for quality and yield in other countries. Most of the imported varieties have proved to be early maturing, and grow with vigour in the country. In the case of barley, also, imported varieties have been grown with success, and it seems likely that, as in the case of wheat, an imported barley yielding grain suitable for export can be placed in the hands of cultivators years before one as good can be produced by crossing and selection from local material. The chief work to be done with barley is in connection with improving the yield of grain and the strength of the straw ; the native varieties are remarkably weak in the straw, and severe losses are caused by crops being laid flat by late rains and hailstorms.

The *Report* contains a classification of fifty-one local varieties of wheat, of which twelve are awnless and twenty-one awned varieties of *Triticum vulgare*, and eighteen are durum (macaroni) wheats. The chief regions for durum wheat are the Mosul Vilayet and the northern part of the Karun River area, whilst it is also met with, sometimes as a very pure crop, in the Kut area. Elsewhere in the areas investigated bread wheats (*T. vulgare*) are mainly grown.

In the irrigated tracts, roughly definable as the area south of the Jabel Hamrin, barley is grown in preference to wheat owing largely to the uncertainty of the latter crop which is liable to severe epidemics of rust. Six varieties of barley are enumerated, the most suitable kind for cultivation under " daim " conditions (i.e. where the crop is dependent solely on the natural rainfall) being a two-rowed black barley, which is specially suited for feeding purposes. A two-rowed white malting barley is grown for export in the Karun area.

The various cultivation methods practised may be grouped under five heads : (1) " Daim " cultivation referred to above, as in the Karun River and Mosul areas ; (2) " Chibis " cultivation, by means of residual under-

ground water remaining after the drying up of a flooded area, supplemented by natural rainfall, as in the Akkarkuf area and the areas along the Ghurraf; (3) by means of lift irrigation supplemented by natural rainfall, as practised along the river banks throughout the country; (4) by means of natural rainfall assisted by flood water from inundation canals in spring, as in the area between Qal'at Saleh and Ctesiphon; and (5) by irrigation water from perennial canals, supplemented by natural rainfall, as in the areas supplied by the canals which take off from the Euphrates above the Hindijah barrage. On these last-named areas (5) the land can be softened by irrigation so that ploughing can be done in the autumn, thus enabling the seed to be sown at the proper time. On all other tracts the commencement of ploughing and sowing is dependent on the rains. Nevertheless, the quality, rust resistance, and, very often, the yield per unit area, tend to be adversely affected by an abundant supply of water, since, where plenty of water is available, there is a tendency for the cultivator to apply too much, a harmful practice on alluvial soil, which is extremely liable to cake after irrigation or even after rain. Further, the perennial irrigation tracts are rapidly becoming saline owing to the excess of water used. If the land were harrowed after rain it seems probable that only two irrigations would be necessary in these tracts, one in the late autumn immediately prior to deep ploughing and one in early April at the time of appearance of the wheat and barley ears.

The World's Supply of Metals and Minerals.—The following notes are taken from the recently published work on *Political and Commercial Geology and the World's Mineral Resources*, a notice of which is given on page 574 of this BULLETIN. The sections of the book are written by specialists and were originally issued separately by the United States Bureau of Mines.

Petroleum.—The United States controls 90 per cent. of her own production, and 65, 70 and 80 per cent. respectively of that of Mexico, Peru and Canada—the last being exercised through a virtual monopoly of pipe-line and refining facilities. Attention is drawn to the significance of the concession, half a million square miles in extent, recently granted by the Persian Government to the Anglo-Persian Oil Co., a majority of whose shares are owned by the British Government. Notwithstanding America's present strong position in oil, the author believes that, unless the United States adopts measures, such as Federal operation of the trunk pipe-lines in the United States

itself, and the protection of investments of United States citizens in other countries, particularly in Latin America, " it may witness its commercial supremacy in petroleum affairs wane and disappear, while it is yet the largest contributor to the world's supply of petroleum."

In the opinion of the author, the most conspicuous petroleum developments in the next decade will take place in the countries that border the Caribbean Sea and the Gulf of Mexico, *e.g.* Mexico, Venezuela, Colombia and Trinidad. The ultimate position of Russia, as the leading oil-producer of the world, seems reasonably assured. An increase in output may be looked for from India, Persia, Mesopotamia, Japan, Formosa and the Dutch East Indies, and oil-fields may possibly be developed in Asia Minor, Turkestan and China.

Coal.—The United States is in a very enviable position as regards coal, holding nearly half the total world reserves of 7,900,000 million tons, as compared with Great Britain's 190,000 million tons. It seems that in a century the United States will surpass all Europe in coal production, and is therefore " likely to be a centre of manufacturing wealth ; and with this will come an equally certain continual increase in population and power." Owing to the increased cost of coal in Great Britain, there is every probability that the United States will be able to compete successfully in export business, not only in South America but also in Mediterranean ports.

Iron.—More than two-fifths of the total annual output of iron ore in the world has come from the United States, and 80 per cent. of this from the Lake Superior district.

Owing to the war, the Bohemian deposits, estimated to contain 35,100,000 tons of high-grade ore and 221,800,000 tons of low-grade ore, come under the control of Czecho-Slovakia ; Bosnian ores, with an estimated reserve of 21,500,000 tons, belong to Yugo-Slavia ; and the Lorraine district, the annual production of which amounted to upwards of 40,000,000 tons, has passed to France. In 1916 Japan produced 158,815 tons of iron ore and imported 192,225 tons from Korea and 282,149 tons from China, and has a rapidly expanding steel-making industry.

Manganese.—The United States has an abundance of low-grade ferruginous manganese ore, which is used, ordinarily, for the manufacture of spiegeleisen. The known deposits of manganese in Africa are few and relatively unimportant, but that continent offers an unusual prospect for the discovery of laterisation-deposits that will contribute largely to the world's supply.

Chromium.—The United States leads in the manu-

facture of chromium products, such as ferrochrome and chrome chemicals, and consumes more than one-third of the world's production of chromite, but is dependent to a large extent on the good-will of England (Rhodesia) and France (New Caledonia) for a continuous supply of chromium ore.

Nickel.—In 1916 Ontario was responsible for 80 per cent. of the world's production. Of the four companies mining in the Sudbury district, two are American, and possess the largest reserves there, and one of them has the next to the largest holding in New Caledonia. Great Britain is in the strongest position politically of all nations, and the Canadian Government has insisted on the transfer of the refining operations of the (United States) International Nickel Co. from New Jersey to Ontario, and has itself a controlling interest in one of the two remaining (British) companies, thereby marking " a vigorous and aggressive nationalistic policy which has attained its object without much delay."

Tungsten.—In 1917 and 1918 the United States and Great Britain controlled, respectively, 59 and 35·3 per cent. of the world's output. The author is of opinion that, should the United States pass the proposed tariff law, she will cut off her foreign supplies of tungsten ores, and end her control of any considerable part of them. Moreover, in 1913, Germany controlled two-thirds of the world's output of tungsten ore, and by such a tariff she may easily recover a large part of her control of the world's tungsten trade. To prevent this, the author advises the purchase and storage of about 10,000 tons of Chinese ore, so that the United States, with its own production, may have within reach at least a year's supply. " The Pacific, around the borders of which are the largest tungsten deposits, is by many looked upon as the next large theatre of war, and, however vitally they were needed, the obtaining of supplies of tungsten ores might become impossible through the blocking of trade routes."

Vanadium.—The United States is practically the only producer of vanadium in the world, and controls the large deposits of San Miguel County, Colorado, as well as the still more important ones of Minasragra, Peru. The low-grade roscoelite (vanadium mica) deposits of Colorado are large and easily worked, and so can be mined at a profit. A considerable amount of vanadium is also obtained as a by-product from the treatment of carnotite (uranium and radium) ore occurring in Colorado and Utah.

Antimony.—Since 1908 over 50 per cent. of the world's total antimony production has come from China, which can manufacture antimony far more cheaply than is

possible in Europe or America. Chinese antimony has become firmly established in the United States markets, and "its quality has proved equal to the best English grade."

France has important deposits in Algeria, and, moreover, is the only world-power that possesses important resources of antimony within her boundaries.

Radium and Uranium.—The United States is to-day the largest producer of radium and uranium ores in the world, and of manufactured radium and uranium compounds. The carnotite deposits of South-Western Colorado and South-Eastern Utah occur as impregnations in sandstone, and the production amounts now to several thousand tons of ore per annum. In Gilpin County pitchblende is found in small quantity in gold-bearing veins.

Copper.—The United States produces 60 per cent., and American capital controls 78 per cent. of the world's production, so her position in that respect is unassailable. The fact that Germany, prior to 1914, was the biggest foreign buyer of United States copper "made easy the successful development of the carefully laid German plans." The author thinks that, in the future, such plans can be guarded against by encouraging copper producers to sell their own output. The export copper business should be handled through one agency or association, representing all the sales agencies, as is now legal, and this should be done in the interests of the producer and of the country.

Lead.—The United States produces 44·6 per cent. of the world's output of lead. The Bawdwin mines of Burma will be the chief new factor in production, as they are being developed on a large scale, so as to produce 300,000 tons of ore annually. The author believes that the British Empire can be made independent of the rest of the world as regards lead, should the policy of "Imperial preference" be adopted.

Zinc.—In 1913 the United States supplied 35 per cent., Germany 25 per cent. and Australia 15 per cent. of the world's production of zinc. With the permanent diversion of the Australian concentrate, and the probable loss of the Silesian deposits and reduction works, Germany will lose the second place in the industry, and her supply of domestic ore will be reduced to one-third of that produced before 1914. The British Empire, as a unit, should be able to dominate the industry in Europe during the near future, and the position of Germany will depend mainly on the supply of foreign ore, which may have to be imported largely from Mexico and the United States.

Tin.—British capital controls 57 per cent. of the

world's output of tin, and partially controls 15 per cent. more. The Bolivian tin-mines are the only ones in the world in which British control is not strongly felt. During the war a tin-smelting industry was established in the United States, which depended chiefly on Bolivian ore. To meet the ore requirements the author hints that the United States should obtain financial control of enough ore deposits in Bolivia to supply the demand, and states that a New York firm has recently acquired some mines in that country.

Bauxite and Aluminium.—The United States and Canadian plants are producing over one-half of the world's supply of aluminium, and are controlled by the (United States) Aluminium Company of America. This company should be in a position to dominate the aluminium industry of the world for some years through the expansion of its electrical plants and its initiative in acquiring newly discovered deposits of exceptionally pure bauxite in South America. It is reported to control 2,030,000 acres of bauxite-land in the British and Dutch Guianas. Before the war some of the large French deposits were controlled by German interests. "It seems quite conceivable that the British and French, and possibly the German interests, may seek to adjust their relations so that they can offset the American dominance."

Mica.—The British Empire controls 75 per cent. of the present sheet-mica production of the world. The most important producing amber mica (phlogopite) mine in Canada is owned and operated by the General Electric Co. of New York, which also has a large mica-manufacturing plant at Ottawa, Ontario. The editor thinks that "a permanent British monopoly of the mica market can probably best be obviated by the development of the Brazilian field by American electrical manufacturers."

Asbestos.—Great Britain controls 88 per cent. of the asbestos output of the world, and approximately 70 per cent. of the world's reserves. The chrysotile or fibrous serpentine deposits of Canada supply 85 per cent. of the world's annual production, and the United States, which leads all nations in the manufacture of asbestos products, in 1916 used 86 per cent. of the Canadian output. The editor writes: "Should the British policy as to other mineral industries be carried out in the case of asbestos, we may expect action on the part of the British or Canadian Government to transfer the centre of asbestos manufacture from the United States to Canada or England."

Gold.—It is pointed out, that, although Great Britain and the United States in 1913 controlled 62·9 and 19·3

per cent., respectively, of the world's production, the control of fields in Siberia and South America, likely to be of importance in the future, is in the hands of neither Power.

Platinum.—The author states that the most important platinum-bearing placers of Colombia are controlled by American financial interests; this control is likely to continue unless conditions are changed by special legislation in Colombia.

• **The Relation between Bacteria and Certain Iron and Manganese Ores.**—More than eighty years ago Ehrenberg investigated a certain bog iron-ore and found it to consist of the remains of algæ. In this connection it is of interest that a few years ago (or just prior to 1915) Albert Orion Hayes made a microscopic examination of the Wabana hæmatite of Newfoundland, and found fossil tubules of minute boring algæ in shell fragments, spherules, phosphate nodules and siderite in the ore ("Wabana Iron-ore of Newfoundland," *Memoir* 78, 1915, *Geol. Surv., Dept. Mines, Canada*, pp. 28, 74, 75). Ehrenberg had observed in the marshes near Berlin a substance of a deep ochre-yellow colour passing into red, which on microscopical examination proved to be composed almost entirely of *Gallionella ferruginea*, one of the iron-bacteria, but Ehrenberg himself mistook the organism for a diatom. Many years later Hans Molisch found the remains of iron-bacteria in three bog iron-ores, out of thirty-four iron ores examined by him. Later, the same investigator examined twenty-seven more specimens of ironstone. He published his results in 1910, and in a limonite of the class known as *Raseneisenstein* (meadow ore or bog iron-ore) he found, here and there, inside holes, ochre masses made up almost entirely of fragments of the sheaths of *Leptothrix ochracea*, which is said to be by far the most widely distributed of all iron-bacteria, having been found universally distributed in ferruginous waters in every country throughout the world. David Ellis, of the Royal Technical College, Glasgow, discovered a new species of iron-bacteria near Glasgow: he named it *Spirophyllum ferrugineum*, but he thinks it highly probable that *Spirophyllum*, *Leptothrix* and *Gallionella* may be pleiomorphic forms of one and the same organism (*Iron Bacteria*, 1919, p. 38). According to Edmund Cecil Harder, *Spirophyllum* is more widely distributed in American iron springs, mine-waters and iron-bearing well-waters than *Leptothrix*. In one locality he found it occurring in a mine-drift, at a depth of 300 feet, in gelatinous masses near openings where iron-bearing waters issued, and associated with *Gallionella*

and *Leptothrix*. "It opens the interesting possibility that not only may these be instrumental in the formation of surface bog ores, but they may play a part in the formation of certain underground deposits of limonite, such as those which occur in the Appalachian region." ("Iron-depositing Bacteria and their Geologic Relations," *Professional Paper* 113, 1919, *U.S. Geol. Surv.*, p. 80.)

Tyrrell, of Glasgow University, is of the opinion that the Clayband ironstone of this country is the bog iron-ore of the Carboniferous period.

Hitherto, no structures—recognisable as the fossilised remains of iron-bacteria—have been discovered in rocks of older date than bog iron-ore. David Ellis recently examined the Frodingham ironstone, which is a ferruginous, fossiliferous limestone, with distinct oolitic structure, of Lower Lias age. The bulk of the ore is a hydrated iron peroxide or limonite. A search for fossils in the ore revealed the presence, not of iron-bacteria, but of an iron-secreting thread fungus. In this connection it may be mentioned that Harder, the American investigator of iron-bacteria, has found that the mycelia of various fungi often become impregnated with, or coated by, ferric hydroxide (*op. cit.*, p. 11). Ellis concludes that the fossil mould of the Frodingham ironstone "had collected the iron on its membrane in precisely the same way as do the iron-bacteria to-day. That is to say, it must have lived in a ferruginous medium, and the iron in it was collected during its lifetime" (*op. cit.*, pp. 171, 172).

Herdsman has sought to prove the organic origin of the sedimentary ores of iron because many of them are highly phosphoric, but, although the phosphorus in the ore may be organic in origin, it does not follow that the ore itself has an organic origin. This argument may be carried too far: Cleveland ironstone, which occurs in seams in the Middle Lias, and the structure of which is generally oolitic, carries from 1 to 3 per cent. of phosphorus, which seems to point to an organic origin, but the Frodingham ironstone (Lower Lias) of Lincolnshire only has from 0·2 to 0·5 per cent., the Neocomian (Lower Cretaceous) iron-ores of Lincolnshire, and the Northamptonshire and Rutlandshire ironstones (Lower Oolite), carry about 0·5 per cent. of phosphorus, and although the "rakes" (ironstone nodules) of Derbyshire (Carboniferous) may range from 0·5 to even 1 per cent., they sometimes only contain 0·1 per cent. of phosphorus. The only Bessemer ore in the United Kingdom—the red hæmatite of the North of England—which occurs as irregular masses in Carboniferous limestone, produced, it is believed, by metasomatism of the limestone

through mineralising solutions, contains as little as 0·013 per cent. of phosphorus, yet the irregular pockets of brown hæmatite occurring in the Carboniferous limestone of the Forest of Dean, Gloucestershire, which presumably are of similar origin, carry as much as 0·65 per cent. of phosphorus (Henry Louis: "The Iron-ore Resources of the United Kingdom"—*The Iron Resources of the World*, vol. ii, 623–41). Again, the ferriferous bauxite of County Antrim, North Ireland, which is a lateritic ore, apparently produced by weathering under tropical climatic conditions of portions of basalt which overlies it, is usually very low in phosphorus, yet James Strachan in 1911 said: "These deposits (iron-ore, bauxite, lithomarge, etc.) represent a slow transition from a moist land-surface to true lacustrine conditions, and during the latter period iron-bacteria probably played an important part in the formation of the sediments" ("The Inter-Basaltic Rocks—Iron-ores and Bauxites—of N.E. Ireland," by G. A. J. Cole, *Mem. Geol. Surv. Ireland*, 1912, p. 12). This conclusion, however, has not met with general support.

The phosphorus in the Wabana (Newfoundland) hæmatite averages about 0·6 per cent. Hayes found an intimate relationship between the amount of shell fragments and the percentage of phosphorus in the ore rocks at Wabana, and he concludes that the organic remains are the principal source of the phosphorus and calcium of the ore (*op. cit.*, p. 40).

It has been shown that the iron-bacteria are by no means the only organisms on which iron collects in abundance. Reference has already been made to thread fungi and algæ. Certain algæ collect iron in abundance when growing in ferruginous waters, and the property is also characteristic of certain protozoa. According to Herdsman, an iron-ore placed on a shelf became coated with the organism familiarly known as "dry rot" (*Merulius lacrymans*), which assumed a red hue and threw off spores. The assay of the spores showed them to possess the same iron content as the ore itself (Ellis, *op. cit.*, p. 174).

Some of the iron-bacteria will, under certain conditions, take up manganese. It has been shown that *Crenothrix polyspora*, the pest of reservoirs, will take up manganese as readily as iron. The *Crenothrix manganifera* of Jackson is probably not a distinct species, but an example of the effect produced in *C. polyspora* by living in a medium highly charged with assimilable manganese (Ellis, *op. cit.*, p. 63). Molisch has shown that *Leptothrix ochracea* will thrive abundantly on iron-free culture media consisting of distilled water with 1 or 2 per cent. of peptone. However, if iron

is present, the organism will show better development, and will deposit ferric hydroxide in its sheath, and, if manganese salts are present, it will deposit hydrated manganese oxide in its sheath (Harder, *op. cit.*, p. 78). This may possibly explain the intimate association of iron and manganese ores in certain deposits. Investigations by W. D. Francis show that ferruginous and manganiferous material in bogs and streams at Kin Kin, Queensland, is composed very extensively, if not entirely, of micro-organic material, chiefly bacterial. A few algæ, and, less frequently, protozoa, are also present ("The Origin of Iron and Manganese Ore in Bogs and Streams," *Proc. Roy. Soc. of Queensland*, 1916, **28**, 80). In this connection, it is interesting to note that Dana, in his *System of Mineralogy*, mentions that at Glendre, in the County of Clare, Ireland, a layer of rhodochrosite, 2 inches thick, occurs below a bog and has a yellowish-grey colour. It appears possible that certain stratified beds of manganese carbonate (rhodochrosite) have been at least partially formed by iron-bacteria, *e.g.* the manganese carbonate beds of the Cambrian (Ordovician) formation of Merionethshire, North Wales, and beds of the same mineral in rocks of very similar age at Las Cabesses, Pyrenees, France, at Chevron, Belgium, and in Canada, Newfoundland, Arkansas, and other countries.

It must be admitted, however, that our present knowledge is still somewhat meagre, and that it is not possible to come to definite conclusions as to the exact extent to which organisms have taken part in the building up of ferruginous and manganiferous ores. All that can be said at present is that iron-bacteria are responsible for the formation of ferruginous and manganiferous sediments, which probably form themselves by slow degrees into iron and manganese ores.

RECENT PROGRESS IN AGRICULTURE AND THE DEVELOPMENT OF NATURAL RESOURCES

In this section of the Bulletin *a summary is given of the contents of the more important papers and reports received during the preceding quarter, in so far as these relate to tropical agriculture and the utilisation of the natural resources of the Colonies, India and the Tropics generally. It must be understood that the Imperial Institute accepts no responsibility for the opinions expressed in the papers and reports summarised.*

AGRICULTURE

Foodstuffs and Fodders

Prickly Pear.—The present position regarding the utilisation of the prickly pear plant as a fodder is briefly reviewed in *Journ. Dept. Agric., Union S. Afr.* (1920, **1**, 848). The plant is of value chiefly in arid countries during periods of drought. The spines on the leaves must be removed, as they cause purging, and the thorns on the fruit are also a source of danger. In the United States the most common practice is to remove the spines by singeing, for which either a plumber's blast-lamp or a bush fire is employed. An alternative method consists in boiling or steaming the leaves for some hours. For feeding to stock the leaves are chopped up and mixed with more concentrated food, for the fresh leaves consist mostly of water and the material is not rich in nourishment unless dried.

In *Farmers' Bull.* No. 1072 (1920), *U.S. Dept. Agric.*, on "Prickly Pear as Stock Feed," attention is also drawn to the importance of this plant as a reserve fodder. In Southern Texas the wild crop has enabled the rancher to keep his herd intact through periods of drought ranging from three months to three years. In this *Bulletin* the subject is fully discussed, including the cultivation of the so-called spineless forms, which are stated to be sufficiently devoid of spines to enable cattle to feed on the untreated plant without harmful effects.

Oat Grain and Straw.—The results of extensive investigations spread over many years and forming a systematic study of the influence of variety, soil, climate, manures, etc., on the composition, character, and yields of oat grain and straw are given in *Journ. Agric. Sci.* (1920, **10**, 359). Analytical data are published which include the composition of the kernel, straw, chaff, and husk at successive stages of growth. It is shown that the yield per acre is associated directly with the average size of the individual grains sown. The larger grain gives the greater yield of grain, greater weight per bushel, and larger

proportion of kernel. The yield per acre of nitrogen in the dry kernel is also greatest in the case of the heavier grain, although the latter contains a lower percentage of nitrogen than the smaller grain.

Digestibility of Straw after Treatment with Soda.—In *Journ. Agric. Sci.* (1920, **10**, 437) are recorded the results of an examination of the practical possibilities of soda treatment for increasing the digestibility of straw. Crude straw is not only low in digestibility, but the digested portion is of low value in comparison with material digested from other foods. The principal reason for the low digestibility of straw lies in the fact that the digestible matters are embedded in indigestible lignified tissue, which protects them to a considerable extent from the action of the digestive juices. Frequent attempts have been made to overcome this difficulty by fermentation or treatment with caustic soda. The latter process has proved fairly successful, and a method applicable to farm conditions has been devised. The chopped straw is soaked overnight in a 1·5 per cent. solution of caustic soda, and, after draining, is transferred to a vertical iron boiler into which steam is introduced. The whole mass is raised to the boiling temperature and maintained in that condition for one hour. Feeding trials were carried out with the treated straw, the results showing that there is a clear gain of nutritive efficiency. The figures indicate that, for maintenance purposes, the dry matter of the treated straw has roughly one and a half times the value of that of the untreated straw, whilst for production purposes its value is nearly double. This process must be looked upon as a reserve measure in times of necessity, as the cost of production leaves no margin for profit. A cheaper process has been devised recently by Beckmann in which heating is entirely dispensed with, the straw being soaked in a cold solution. Digestion trials showed the product to have a nutritive value equal to that of the straw treated by the hot solution, but the risk involved in the handling of caustic soda by labour ignorant of its properties is an important objection to its adoption.

Lespedeza as a Forage Crop.—*Farmers' Bull.* No. 1143 (1920), *U.S. Dept. Agric.*, deals with the cultivation and use of this legume as a pasture and hay crop. Lespedeza, or Japan clover, is considered to be the best summer legume pasture crop for poor soils which has so far been introduced into the south-eastern parts of the United States. On alluvial soils the growth is sufficient for the

production of hay, yields of one to three tons per acre being commonly obtained.

Cowpeas.—*Farmers' Bull.* No. 1148 (1920), *U.S. Dept. Agric.*, contains recent information on the varieties and culture of the cowpea, including its growth for hay in combination with such crops as sorghum, Sudan grass, Johnson grass, soy beans and millet. When grown in this manner not only is a greater variety and larger yield of fodder obtained, but the mixed hay is more easily cured and handled.

Oils and Oil Seeds

African Oil-palm.—During the last few years the oil-palms of the Congo have been carefully studied by several observers, and the results of two of these have recently been published. The oil-palms in the district of Mayumbe are described by Comte de Briey in the *Mission Forestière et Agricole au Mayumbe*, 1920, p. 371. The palms in this district are scattered throughout the forests, but occur in the greatest number in the north-east of Mayumbe, where they form large groves. In such cases, the average number of productive palms per hectare is about fifteen (six per acre), while in the large tracts of virgin forest there are only five of these trees per hectare (two per acre). It is calculated that the average age to which the oil-palm grows in Mayumbe is from 100 to 150 years. Ninety per cent. of the oil-palms here belong to the sub-species *Elaeis nigrescens*, of which there are three well-marked varieties, namely : *E. nigrescens* var. *communis*, which is nearly identical with the type found in Dahomey and the Ivory Coast ; *E. nigrescens* var. *sempernigra* (*a*) with long spines, (*b*) with short spines. The remaining 10 per cent. belong to *E. virescens*. A botanical description of the oil-palm is included in this article, special attention being given to those points on which the author differs from Chevalier (*Documents sur le Palmier à Huile*, 1910). Tables are also given, in which are shown the average weight of the bunches, the weight and dimensions of the fruits, and the composition of the bunches and fruits.

The oil-palms in the neighbourhood of Coquilhatville, Belgian Congo, have been studied by Tihon, and his results are published in *Les Matières Grasses* (1920, p. 5648). The oil-palms in this region can be divided into two main groups, namely, those with fruits that are black before ripening, and those with fruits that are green before they ripen. In the first group is included the *Elaeis* sp. that is known to the natives by the name of "eolongo,"

of which there are seven types, differentiated by the colour and size of the fruits and the percentages of palm oil and kernel they contain. The "djongo" palm, which is identical with Preuss's "Lisombe with large fruits," also comes under this heading. The other group includes the "eseke" palm, of which Tihon met four different types.

From the tables given by Tihon, in which are shown the composition of the bunches, fruits and nuts, together with the percentages of oil in the pulp and the kernels, it would appear that the "djongo" palm gives the return of highest value for palm oil and palm kernels taken together. Unfortunately, this variety is rather rare in this part of the Belgian Congo. It gave the largest yield of pulp, *i.e.* 86 per cent. on the fresh fruit, the pulp containing 56 per cent. of oil. The highest yield of kernel oil was given by "n'kalanga," the fruit of which contained 52·5 per cent. of kernels, containing 43 per cent. of oil. Trials were made to ascertain the best method of extracting the oil from the pulp, and, of the methods tried, the dry pressure method was found to give the largest yield of oil. In this method the fruits are warmed on a fire, the pulp is removed by pounding in a mortar, and the separated pulp is rewarmed and then treated in a press, such as that used for limes.

Chia Seeds.—Experimental trials have been carried out on expressing the oil from Chia seeds (*Salvia hispanica*) from Mexico,and a yield of 22·3 per cent. of oil was obtained. The expressed oil was clear, of a light amber colour, and had an iodine value of 196·3 per cent. Drying tests showed that the raw oil dried rather slowly, but, when mixed with suitable driers, it dried as quickly as linseed oil. Arrangements are to be made for the experimental cultivation of these seeds in the United States (*Educ. Bur., Paint Manuf. Assoc., U.S.A., Circ.*, 105, 1920).

RUBBER

Hevea

Influence of Variation in Tapping on the Composition and Properties of Latex and Rubber.—The *Archief voor de Rubber-cultuur* (1920, **4**, 313) contains an account of a series of experiments to study the differences in latex occasioned by varying the manner and extent of tapping. It was found that, in general, lengthening the tapping cut had the same effect as heavier tapping. The rubber content of the latex decreased, and the rubber vulcanised

more quickly. The differences recorded, however, are not so great as to be of any importance in the choice of a tapping system; for instance, in changing the cut from one-third to one-quarter of the circumference, decrease of five minutes in the time of cure resulted. It is thought, however, that the length of cut, with other factors, may explain the differences between rubber from different estates prepared by the same standard methods.

In a second group of experiments increasing the number of tapping cuts on one surface was found similarly to decrease the rubber content of the latex and lessen the vulcanising period of the rubber. Experiments with tapping on two opposite quarters of the trunk at two different heights, namely, 20 and 70 centimetres (8 and 28 in.) from the ground, showed the rubber from the two cuts to have practically identical properties; but the lower cut yielded more than three times the amount of latex obtained from the upper incision. Tapping twice daily on the same cuts, at 6–8 a.m. and 10–11.30 a.m., yielded rubber having the same properties in both cases; but the yield of latex from the later cut was only two-thirds of that of the early cut.

In further experiments, tapping cuts penetrating to the wood of the tree were found to effect the usual changes caused by heavier tapping. This treatment on trees already subjected to a heavy tapping system gave abnormal latex, on some days containing only 16 per cent. of rubber and having a specific gravity of 1·0002. Tapping on portions of bark isolated by cuts to the wood resulted in latex with less than 10 per cent. of rubber, and in one case with as little as 3·77 per cent. The first tappings on these trees, made a few days after the bark had been isolated and a large amount of latex had already flowed out, did not give the yellow latex with high rubber content and the resulting slow-curing crêpe, generally obtained when opening a tapping cut. This is regarded as indicating that such abnormal latex, obtained in a first tapping, is the primary or stationary latex whilst the secondary latex is that formed after tapping commences, and gradually replaces the primary latex. It has a different composition from that of the latter latex, and this explains the well-known changes that occur in the properties of the latex and rubber during the early period after opening a cut.

The concluding group of experiments on tapping at different hours of the day showed no difference in the properties of the resulting rubber, but the rubber content of the latex from the afternoon tapping was somewhat

higher than in the case of earlier tapping. Rubber from experiments in which tapping with and without drip-tins had been carried out showed no difference in properties, provided the latex had been diluted in both cases to the same rubber content. It was, therefore, not possible to detect any influence of substances extracted from the bark, and the results are not in agreement with the conclusion of P. Arens, that the use of drip-tins is not advisable.

FIBRES

Sisal Hemp.—Reference is made in *West Africa* (November 27, 1920, p. 1502) to an experiment in the cultivation of Sisal hemp which has been undertaken by the Gold Coast Government on an estate of 3,000 acres, about 2½ miles from Accra, with which it is connected by a light railway. About 500 acres have been cleared and 300 acres have already been planted with Sisal hemp which is growing satisfactorily. Between the rows of young plants various catch-crops are being grown, including cassava, beans, maize, wheat and cotton. When the Sisal plantation has become established tramways are to be laid down and machinery introduced. The object of the experiment is to give employment to the natives in districts where other commercial crops, such as cocoa, are not grown, and to encourage them to plant Sisal hemp on their own account.

Paper-making Materials

Baobab Bark.—A report on the investigation at the Imperial Institute of the bark and wood of the baobab tree has been published in this BULLETIN (1917, **15**, 326). A detailed study of the bark has now been made by F. Heim in collaboration with L. Matrod and F. Moreau, and the results are published in *Bull. de l'Agence Générale des Colonies* (1920, **13**, 1065). The bark has been submitted to microscopical and microchemical examination, and technical trials have been made to determine its value for paper manufacture. The raw material employed consisted of reddish-white ribbons of the inner bark which had been neither retted nor combed. On treatment with caustic soda solution a yield of 33 per cent. of pulp was obtained, this figure being identical with that obtained at the Imperial Institute (*loc. cit.*). The pulp furnished a soft, flexible, white paper with a satisfactory resistance to tension, tearing and rubbing. The fibres of which the pulp was composed had an average length of 3·9 mm., an average diameter of 40 μ, and were rounded at the

ends; they had a felting power of 0·011, which is sufficient but is inferior to that of esparto, jute, bamboo, hemp and cotton. The conclusion is drawn that baobab bark would be very suitable for paper-making if obtainable in regular supplies and at a sufficiently low cost to enable it to compete with other raw materials.

Bog Grass.—It is stated in *Commerce Reports* (1920, No. 273, p. 799) that a mill has been erected in Argentina for the manufacture of paper pulp from a species of bog grass, known as "paja brava." This grass grows throughout the year, and is so abundant in swampy places as to be regarded as a pest. The mill is at present equipped merely for the manufacture of pulp and strawboard, and has a capacity of three tons of strawboard a day. It is hoped to improve the present installation at a later date with a view to obtaining an increased output and the production of a better quality of pulp.

Jack Pine.—An article has been published in the *World's Paper Trade Review* (1920, **74**, 2128) on the utilisation of the jack pine (*Pinus Banksiana*) for paper-making. This tree, which is also known as the banksian pine or cypress, grows over enormous tracts in the Provinces of Ontario and Quebec. An investigation of the wood by a firm of paper-makers in Quebec has shown that it contains very little resin, and that, when treated by the sulphate process, it yields a pulp which is fully equal to spruce pulp. The length of the fibres ranges from 1¼ to 3 mm. with an average of 2·26 mm., and is thus greater than that of spruce pulp, which varies from 1¼ to 2½ mm. with an average of 1·92 mm. This superiority in the length of fibre in the jack pine pulp renders it particularly suitable for the production of newsprint paper.

Papyrus.—Attention has recently been drawn (*L'Agronomie Coloniale*, 1920, **5**, 165) to the enormous areas of papyrus which exist in the French Congo and the possibilities they offer for the manufacture of paper pulp. In 1919 a concession of about 10,000 hectares was granted to the Société Industrielle du Bas-Ogoué, and a survey has shown that at a single point on the Ogoué there is sufficient papyrus to supply several factories. The papyrus areas of the Bas-Ogoué can be divided into three classes according to the density of the growth: (1) the less dense areas, from which 145 tons of green papyrus per hectare can be obtained at one cutting; (2) areas of medium density yielding 240 tons per hectare at one

cutting; and (3) very dense areas from which 295 tons per hectare can be cut. As it seems possible to obtain two cuttings per annum, the annual yield of green papyrus in the three cases would be 290 tons, 480 tons and 590 tons respectively, or an average of 450 tons. The green papyrus contains about 88 per cent. of moisture, and it is estimated that it will yield 4·80 per cent. of its weight of dry pulp, whence the average annual yield of dry pulp obtainable would be about 20 tons per hectare. Reference is made to certain trials which have been made in the manufacture of pulp from the papyrus of the French Congo which have given encouraging results.

Terminalia Arjuna Fruits.—In 1900 *Terminalia Arjuna* was introduced into the Experiment Station at L'Ivoloina, Madagascar. Fruits from these plants have been investigated in the laboratories of the Jardin Colonial, Nogent-sur-Marne, France, and the results are reported in *L'Agronomie Coloniale* (1920, **5**, 111). It was found that the fruits contained only about 3 per cent. of tannin and were therefore of no value as a tanning material. They were therefore examined as a possible material for paper-making, and were found to yield 29 per cent. of pulp. The pulp was composed of fine, long fibre and furnished a good, strong paper. It is considered that the fruits of *Terminalia Arjuna* would constitute a suitable raw material for paper manufacture if they could be obtained in sufficiently large quantities.

Cotton

Nyasaland.—In the *Ann. Rep. Dept. Agric., Nyasaland Protectorate for the year ended March* 31, 1920, an account is given of the position of the cotton-growing industry. Since 1916, when the largest crop was obtained which has yet been produced in the country, the area devoted to cotton has decreased owing to war conditions and the need of growing foodstuffs for the forces. After the cessation of hostilities, the area under cultivation continued to diminish on account of the high prices obtainable for tobacco. Renewed interest, however, is now being taken in cotton, and it is anticipated that the production will increase rapidly during the next few years. During 1919–20 the acreage planted by Europeans was only 12,658 acres and the production, 1,467 bales (of 400 lb.), as compared with 18,141 acres and 1,911 bales in the previous year.

With regard to the native cotton-growing industry,

it has for some years been the practice to control the price paid to the natives for the various grades of cotton brought to the markets by fixing a Government minimum price. The object of this was to discourage Indian traders from buying at prices below which the cotton could be profitably grown. Unfortunately, however, "rings" were formed in the market, whereby the Government minimum became the maximum and the natives were thus deprived of the benefit of the rise in price of cotton and found the crop less remunerative than many other industries of less importance to the trade of the Empire. Certain of the rules of the Cotton Ordinance, 1910, were, therefore, amended and a system of auction was introduced at all Government cotton markets, and this has proved a great success. The native cotton industry has suffered a serious check owing to war conditions, the output of seed-cotton during the year under review being only about 300 tons as compared with 365 tons in the preceding year and 1,070 tons in 1917. The production in the various districts was as follows: Ruo, 92 tons 10 cwts.; Lower Shiré, 77 tons 3 cwts.; Mlanje, 57 tons 9 cwts.; West Shiré, 50 tons 1 cwt.; Upper Shiré, 23 tons 3 cwts.; total, 300 tons 6 cwts.

India.—A paper on "Kumpta Cotton and its Improvement," by G. L. Kottur, B.Ag., Cotton Supervisor, Southern Division, Bombay Presidency, has been issued as *Memoirs of the Dept. Agric. in India, Botanical Series*, vol. x, No. 6. It gives a full account of the characters of the kumpta cotton plant, and of the work done during recent years in investigating various strains of this plant grown near Dharwar, and in isolating and developing improved types.

After dealing generally with the characters of *Gossypium herbaceum*, L., the species to which kumpta belongs, the author proceeds to discuss the different types of kumpta itself, and particularly those which occur in the Dharwar district. The soil and climatic conditions of the kumpta tract are described and the local methods of cotton cultivation are indicated.

The kumpta cotton plant is less bushy in habit than most of the other cultivated types of *G. herbaceum*, and has a shorter growing period. It is usually sown in August–September and harvested in February–March. Another difference is that kumpta plants shed the greater part of their leaves at the beginning of the cold season, whereas this does not occur in the case of the *G. herbaceum* cotton of Gujerat. The boll of the kumpta cotton is small

and tapering, the lint is dull and slightly tinged with red, the seeds are smaller and less fuzzy than those of the Gujerat types of *G. herbaceum*, and the yield on ginning is only about 25–26 per cent. There is, however, a great range of variations in an ordinary field of pure kumpta cotton, and a study has been made on the Government farm at Dharwar of the variations in (1) the branching characters of the plant; (2) the shape of the lobes of the leaf; (3) the shape of the bracteole; (4) the length of the petals and style; (5) the number of cells in the bolls; (6) the number of ovules in the cells; (7) the ginning percentage; (8) the weight of the seed; and (9) the average length of staple of the cotton on the seed. The results of these studies, which are illustrated by means of diagrams, show that the characters of kumpta cotton are much less stable than is usually supposed, and it was therefore concluded that, to effect an improvement of the cotton, it would be necessary to determine the types which have the highest value to the grower and purchaser, select those strains which most nearly conform to the requirements, determine whether these breed true when self-fertilised, and, when they do so, to multiply them and gradually replace the present mixture of strains by one which combines the greatest number of desirable characters.

In commencing this work, careful consideration was given to the characters which should be combined in a cotton plant best suited to the tract. The ideal aimed at was a plant which grows quickly, bears only fruiting branches, flowers early, can be completely harvested in two pickings, and produces a cotton of good length of staple and high ginning yield. As the results of efforts to produce such a type, three fixed strains have been obtained by selection from the kumpta cotton grown at Dharwar, and have bred true through several generations. These cottons, which are described below, are termed Dharwar No. 1, Dharwar No. 2, and Dharwar No. 3.

Dharwar No. 1.—This type was selected from erect plants of ordinary kumpta cotton. It produces comparatively few vegetative branches, and the fruiting branches appear early. The flowers are nearly all produced from the tenth to the fifteenth week, whereas in ordinary kumpta flowering continues much later. The latter plant produces 50 per cent. more flowers than Dharwar No. 1, but a smaller number of ripe bolls. Trials made during the five years 1914–1918 have shown that Dharwar No. 1 yields 20 per cent. more seed-cotton per acre than the ordinary kumpta, the increase being due to a greater development of fibre and not to a diminution in the weight of the seeds, as the

seeds are actually slightly heavier. The cotton is of good strength, has an average length of staple of about one inch as compared with about 0·7 inch in the case of the ordinary kumpta, and is regarded as of greater market value than the latter. Dharwar No. 1 was planted on 1,000 acres in 1918, and was distributed to an area of 6,000 acres in 1919, and it is anticipated that it will be largely grown in the future.

Dharwar No. 2.—This was selected from the bushy type of kumpta cotton. It is inferior to ordinary kumpta in yield of seed-cotton, but gives a higher ginning percentage, equal to that of Dharwar No. 1. The staple is inferior to that of ordinary kumpta, and this selection is evidently an inferior type. The stock is being maintained, however, as it may possibly form the basis of a future crossing.

Dharwar No. 3.—This cotton was obtained by selection from a type which was originally produced in 1901, as a cross between two strains of kumpta, but subsequently lost its special characters. It gives a lower yield of seed-cotton than ordinary kumpta, but has a high ginning percentage (average about 32). On the whole, the yield of lint per acre is slightly less than that of Dharwar No. 1. The plant is bushy and flowers late, but is, in general, superior to ordinary kumpta, and a demand for seed of this variety has arisen in the transition tract of the Dharwar district.

Dharwar Nos. 4 *and* 5.—Two crosses have been made between kumpta and another form of *G. herbaceum*, known as "ghogari." Selection from these hybrids has resulted in the establishment of two strains which breed true, and have been termed Dharwar No 4 and Dharwar No. 5. The former is intermediate in habit between the erect and bushy forms; it produces no axillary vegetative branches, flowers early, yields well, and gives a higher ginning percentage than ordinary kumpta, but has a short staple. Dharwar No. 5 is of a bushy habit, and late in flowering; its yield is small, but the ginning percentage is high and the staple is of good length. This cotton may prove useful in some parts of the kumpta tract, but Dharwar No. 1 is generally to be preferred; in any case, however, it will form an excellent basis for crossing with a cotton of good quality and high yield but having a low ginning percentage.

From the results of these investigations the conclusion is drawn that it should be possible to obtain an early cotton with high yield and ginning percentage, and good length of staple. Further work on kumpta cotton will

be devoted to an endeavour to produce a strain combining the good qualities of Dharwar No. 1 with a high ginning percentage.

MINERALS

Iron Ore.—Although the existence of iron at Port au Port, on the West Coast of Newfoundland, was known some twenty-five years ago, it is only quite recently that the deposit at Indian Head, Port au Port, has been properly examined with a view to its economic development. According to *The Canadian Mining Journal* (Nov. 12, 1920, p. 927), the Dominion Steel Corporation started investigations at Indian Head during the summer of 1920. The outcrop of an uninterrupted belt of magnetite and hæmatite, from 3 to 9 ft. in thickness, has been disclosed for a length of two miles. The belt runs a little north of east and south of west, and dips N. 33°. The ore occurs in metamorphosed rocks of Laurentian age, consisting of granites, pegmatites, syenites, diorites, pyroxenite, anorthite and basalt, and appears in bands and lenses, associated with intrusive granite, pegmatite and syenite. The ore is granular or massive in structure, and is said to be of excellent quality, being high in iron and remarkably free from impurities. The composition is said to be very like that of Swedish iron-ores.

The property being explored is situated five miles from the main line of the Reid Newfoundland Company's railroad, and is twelve miles in a direct line from Port au Port, which has a spacious harbour.

Indications seem to show that there is a very large body of workable ore at Indian Head, and that there are some millions of tons of ore in sight along the outcrop alone.

Mica.—The following notes are from a report by H. B. Maufe, Government Geologist of Southern Rhodesia, which has recently been published by the Southern Rhodesia Geological Survey (*Report* No. 10, 1920).

The mica deposits of Lomagundi, Rhodesia, which are now being developed, are situated a few miles west of the Angwa River, and cover an area of about forty square miles. The nearest railway is at Sinoia, sixty-four miles to the south, but the deposits are only a few miles east of the probable route of the proposed Sinoia–Kafue Railway.

The mica occurs in dykes of pegmatite, traversing mica schist, and striking a few degrees west of north. The dykes are from a few inches to fifteen yards in width,

and generally dip steeply to the west. The blocks of mica plates, or "books," are concentrated along the walls of the dykes next the mica schist country. In places there are quartz lenticles, or blows, near the walls of the dyke, occasionally free from felspar, but containing numerous books of mica an inch or two in length. This variety is known on the field as greisen. It resists decomposition, and loose blocks of it on the surface are regarded as indicating a mica-bearing dyke beneath. The mica is muscovite (potash mica), and is of a "ruby" (dark red) or bottle-green colour. It is the *datsi* of the natives. The books lie at all angles near the walls, and sometimes the dykes contain inclusions or "horses" of mica schist surrounded by mica books. The books vary from 4 to 60 in. in length—the majority being between 6 to 18 in.—and from 3 to 6 in. in thickness.

The books, on being taken out, split up into slabs about ½ in. thick. With the aid of a knife these are split up into sheets about $\frac{1}{24}$ in. thick, which are trimmed by shears into irregular polygonal shapes, and then graded, generally into four groups: clear, slightly stained, stained, and densely stained. There are ten sizes in each group, the largest size being 72 in. square or over. It is estimated that 1½ lb. of trimmed mica is a good average yield from 1 cwt. of mica won. Much of the waste is of marketable quality, and could be converted into splittings for the manufacture of mica board, cloth, or paper, while other portions could be pulverised to form ground mica.

It is considered (1) that the quality and quantity of the mica, spread over a large area, are sufficient for the establishment of a regular mica-mining industry; (2) that the deposits are sufficiently continuous to be called "reefs" in the South African sense; (3) that very little capital is needed to work the deposits, which therefore appear to be suitable for the "small men."

According to a correspondent of the *Mining Journal* (Oct. 16, 1920, p. 790), some deposits of amber mica (phlogopite) were discovered recently in Madagascar, which appear to be of considerable value. Exportation on a large scale has already commenced, and several hundred cases were shipped in July 1920. In many instances the sizes are considerably above those found in the London market, and the correspondent writes that he saw slabs of 25 in. square without a stain or crack. The mica occurs near the village called Ambatohabo, on the south-east of the island, and has already been worked to a depth of 90 ft. Fresh pockets and well-defined reefs are con-

stantly being met with. The abundance of the mineral, which is in perfect condition and possesses easy cleavage, has given rise to a new industry in Madagascar, viz. the making of fancy articles in mica, such as trays, collars, and brush boxes, cigar boxes, fans, and sailor hats.

Until a few years ago, the world depended entirely on the Canadian deposits for its supply of amber mica, but for several years past, increasing amounts have been derived from Ceylon, South Africa and South America, and now it appears as if Madagascar might become a serious rival to Canada in the production of that mineral.

Molybdenite.—A recent report by A. Gibb Maitland (*The Mining Handbook*, *Geol. Surv.*, *W. Austr.*, *Mem.* No. 1, Chap. II, *Economic Geology*, Pt. III, sect. vii, 1919) describes the molybdenite deposits at Mount Mulgine, near Warriedar, on the Yalgoo Goldfield, Western Australia, on which some development work has been done.

Mount Mulgine is a rough, isolated, granite hill rising to a height of about 300 ft. above the level of the surrounding country. It consists of granite intersected by veins of quartz and pegmatite, which strike north-west and are practically vertical. The granite is traversed by several narrow dolerite dykes, with a general north-east trend, and which intersect both classes of veins.

Molybdenite occurs in the veins and also in the granite itself. It is usually in flakes, varying in size from minute specks to irregular masses, sometimes, though rarely, about half an inch in diameter. It often appears as crusts in which the flakes lie in radiating groups, producing rosette-like forms. In some cases the molybdenite is associated with and occurs in large masses and ill-defined crystals of pyrite. Occasionally molybdic acid occurs in the glassy quartz, whilst ferro-molybdenite is found in some of the pegmatites. The molybdenite rarely occurs in bunches, and when it appears in this form, the mineral is usually only found along cleavages or cracks, which at times cut across the main zones horizontally.

The deposits, which are of deep-seated origin, seem capable of producing a fair amount of ore, containing about 1 per cent. of molybdenite.

In a recent paper by M. E. Wilson (*Canadian Inst. Min. and Met.*, *Bull.* No. 102, Oct. 1920, pp. 749–754), the property owned by the Renfrew Molybdenite Mines, Ltd., is described as the second most important molybdenite mine in Canada. The deposit is a contact-metamorphic one, between limestone and pegmatite, and the finely divided molybdenite is associated with pyrite and pyrrho-

tite in the deposit, which has a width of from 2 to 20 ft. The ore contains on an average 0·95 per cent. of molybdenite.

Molybdenite also occurs in the lower Ottawa Valley, in dykes and in quartz veins, generally too low grade to be worked ; in thin and irregular veins of pyrite, pyrrhotite and quartz in gneiss ; and as segregations of pyrite, pyrrhotite, etc., in quartz-syenite. Five ore-bodies have produced about 800,000 lb. of molybdenite, but these are no longer being worked. The content varied from 0·5 to 1 per cent. of molybdenite.

Tin Ore.—According to H. B. Maufe (*Southern Rhodesia Geol. Surv., Bull.* No. 7, 1920), in the Enterprise District, Southern Rhodesia, dykes of pegmatite, often several yards in width, occur both in granite and in schist, especially near the margin of the granite batholiths. Some of these have been more or less altered to greisen, and then they usually carry cassiterite. The dykes consist essentially of lithia mica, quartz and potash felspar, with small amounts of other minerals, including cassiterite. Cassiterite occurs in irregular black grains, having an uneven fracture with a somewhat resinous lustre. Where the dyke is coarsely crystalline, the grains are up to one inch in length and generally associated with the quartz, and, where fine-grained, the cassiterite is more evenly disseminated in very small grains. The dykes vary much in direction, some striking due north and south, or a little east or west of north and south, and others nearly east and west. They are usually vertical, or nearly so. Tourmaline appears to be absent. The deposits are very similar to the tin-bearing pegmatite dykes of the Mazoe District to the south of Shamva, and to those of the Ndanga District.

The cassiterite does not occur in shoots in the dykes, but in courses of no very great length and certainly of no great depth. The working of the dykes depends on the possibility of finding one course after another, and here geological theory is not in a position to give much help. It rests with the miner to watch for and follow whatever indications may come in his way.

NOTICES OF RECENT LITERATURE

An Introduction to the Chemistry of Plant Products. Vol. I. On the Nature and Significance of the Commoner Organic Compounds of Plants. By Paul Haas, D.Sc., Ph.D., and T. G. Hill, A.R.C.S., F.L.S. Third Edition. Pp. xiii + 414, Med. 8vo. (London: Longmans, Green & Co., 1921.) Price 16*s*. net.

The first edition of this work was noticed in this Bulletin (1913, **11**, 544). In order that fuller treatment might be accorded to the physiological aspect of the subject, the new edition is being issued in two volumes, the first of which has just appeared. This deals primarily with the more purely chemical problems involved in connection with plant products and has essentially the same scope as the earlier editions of the book. Much of the matter relating to vegetable physiology is, however, being relegated to the second volume, which will be particularly devoted to this side of the subject.

The new volume has been revised and partly rewritten, but, although improved in certain respects, it fails, as in the earlier editions, to give any consideration to many plant products of considerable economic importance, such as rubber, gutta-percha, essential oils and resins. In general, however, the work is well written and will doubtless continue to be of service to those requiring a general text-book on plant chemistry.

Cocoa and Chocolate: their History from Plantation to Consumer. By Arthur W. Knapp, B.Sc., F.I.C. Pp. xii + 210, Med. 8vo. (London: Chapman & Hall, Ltd., 1920.) Price 12*s*. 6*d*. net.

Whilst recognising that there are good recent books in existence dealing either with the manufacture of cocoa and chocolate, or with the cultivation of cacao, Mr. Knapp offers his own brief but comprehensive volume as an attempt "to cover lightly but accurately the whole ground, including the history of cacao, its cultivation and manufacture," for the general reader. He appears to us to have succeeded admirably in his task. At the outset he discriminates sensibly between cacao, the correct name for the raw product, cocoa, the established corruption of that name, which should now be used only for the powder manufactured by expressing part of the butter, and chocolate, prepared without removal of the fat. The historical sketch is confessedly based upon *Cocoa—All About It*, by "Historicus," the late Richard Cadbury, which is now out of print; and the preliminary botanical description

of the only species in general cultivation is fully adequate to the occasion. It might have interested the "general reader" to know that the names of the two main races "criollo" and "forastero" signify native and foreign, and are of Venezuelan origin, the latter stock having come apparently at some remote period from Trinidad, while such varietal names as "amelonado" and "calabacillo" refer more obviously to the form of the fruit. Mr. Knapp wisely adopts a non-committal attitude on such controverted cultural questions as permanent shade and the removal of suckers; but his detailed discussion of the process of fermentation is largely original, and is of such great value to the practical man that it must not be overlooked because it occurs in a merely "popular" book. The statistics of recent production will surprise the non-commercial reader, the marvellous growth of the Gold Coast industry from nothing to 40 per cent. of the world's total production within the last thirty years being a remarkable fulfilment of De Candolle's scientific prediction of 1883: "I imagine it would succeed on the Guinea Coast." The industry is, as the author points out, also interesting as the entirely native-owned creation of the so-called "indolent" West African.

The description of the modern processes of manufacture of cocoa and chocolate is very complete, and, like the rest of the book, is illustrated by really useful drawings and photographs. The by-products of the manufacture, cacao butter and cacao-shell, are described with a correction of the over-statement that the former will keep "for ever" without becoming rancid; and the dietetic value of cocoa and chocolate is lucidly set out. The statistics of consumption are almost as striking as those of production, especially those relating to the United States, which have more than doubled their pre-war consumption, and now use "almost as much as all the rest of the world put together." The book ends with a good bibliography and index, the only criticism which we have to offer being that the former is printed in quite unnecessarily large type.

PLANTATION RUBBER AND THE TESTING OF RUBBER. By G. Stafford Whitby, Ph.D., M.Sc., A.R.C.Sc., Assistant Professor, Department of Chemistry, McGill University. Pp. xvi + 559, Med. 8vo. Issued in the series, *Monographs on Industrial Chemistry*, edited by Sir Edward Thorpe, C.B., LL.D., F.R.S. With 8 plates and 48 diagrams. (London: Longmans, Green & Co., 1920.) Price 28*s*. net.

Nowhere is the importance attained by the rubber industry in recent years demonstrated more strikingly

than in Dr. Whitby's book, the most prominent feature of which is the mass of published researches, both on the preparation and properties of plantation rubber, which the author reviews in a concise and comprehensive manner. This work has been skilfully carried out, and is combined with the information which the author has gained by personal experience of the Malayan industry, thus rendering the volume a valuable scientific treatise.

It is pointed out in the Introduction that plantation rubber, which formed 1·4 per cent. of the world's production in 1907, had risen to 79·5 per cent. of the total supply in 1917, and now amounts to approximately 90 per cent. The total yield of plantation rubber from trees other than *H. brasiliensis* is comparatively insignificant, and the book therefore deals only with rubber from the latter source.

The first part of the work—"The Preparation of Plantation Rubber"—comprises nine chapters dealing with the Para rubber-tree under plantation conditions, and includes the handling of the latex and the factory operations involved in the production of the various grades of rubber. In this section the author deals with the question of rubber yield ; the anatomy of the cortex ; seed selection ; tapping ; the function, composition, and coagulation of the latex ; the chemical character of rubber resins ; tackiness ; rubber proteins ; the rustiness of sheet rubber ; maturation ; and a comparison of plantation with Brazilian rubber.

The second and larger part of the book on "The Testing of Rubber" comprises twelve chapters giving a full account of the physical properties of rubber. This section treats of the stress-strain relations of rubber ; tensile tests ; the technique of vulcanisation testing ; the progressive nature of the vulcanisation process ; comparison of raw rubbers ; the state and rate of cure ; stability of the state of cure ; technical mixes ; viscosity ; elastic after-effect ; the mechanical behaviour of rubber ; and Poisson's Ratio. The chapter on vulcanisation testing is especially valuable to the laboratory worker, and describes, amongst other up-to-date apparatus, the oil-bath vulcaniser which has the advantage that moulds can be introduced or withdrawn at any period without interfering with other samples in the vulcaniser, and also enables a boiler for the supply of steam to be eliminated from the testing installation.

In the first chapter of the book attention is drawn to the work of the Imperial Institute on the utilisation of Para rubber seed for the preparation of a drying oil, and the employment of the residual cake as a cattle food.

Gorter's work in obtaining from Para rubber seed phaseolunatin, originally isolated by Dunstan and Henry from Java beans, is referred to, and his figure of 0·077 per cent. of prussic acid from the kernels is quoted. It should be pointed out that the samples of residual cake examined at the Imperial Institute yielded a much smaller quantity of prussic acid, namely, 0·02 per cent. (cf. this BULLETIN, 1919, **17**, 550).

Most of the pages of this work bear copious footnotes, and an admirable bibliography of 45 pages is appended.

MANUAL OF TROPICAL AND SUB-TROPICAL FRUITS, EXCLUDING THE BANANA, COCONUT, PINEAPPLE, CITRUS FRUITS, OLIVE AND FIG. By Wilson Popenoe, Agricultural Explorer, U.S. Department of Agriculture. Pp. xvi + 474, Med. 8vo, illustrated. (New York: The Macmillan Co., 1920). Price 30*s*. net.

This volume presents in a convenient form the information at present available regarding about one hundred different kinds of tropical and sub-tropical fruits, and indicates that there are a large number which are not yet cultivated on a commercial scale. The reason given by the author for the exclusion of some half-dozen well-known fruits, which are articles of considerable commercial importance, is that they are fully treated by other writers, but it is to be regretted that the works which deal specifically with these subjects are omitted from the bibliography appended to this volume. The author advances, as one of the causes for the lack of really first-class fruit in tropical countries, the ignorance of the art of grafting on the part of the natives. It is well known that temperate countries are far better supplied with fruit of good quality than are tropical and sub-tropical regions, but this is due to the fact that the fruit has been improved by cultivation. Left to themselves, these improved varieties would quickly deteriorate, or become extinct, and they are only maintained by systematic cultivation and artificial propagation. That tropical and sub-tropical fruits are capable of improvement is evidenced by the results obtained with the few kinds that have been subjected to systematic cultivation, and there are possibilities of further successes in this direction. One of the most promising, in the author's opinion, is the avocado of Central America, which is being cultivated on a considerable scale in California, Florida, Cuba, and Porto Rico. As a means of supplementing the food supply of native labour in tropical countries, the cultivation of fruit is strongly urged. Hitherto, the crops that have engaged the planter's

attention, such as rubber, coffee, tea, cotton, etc., have been intended primarily for export purposes, and have not increased the local food supply. The author therefore pleads for broader views in connection with tropical developments, and urges that the food supply of the native population should receive consideration, as well as export crops. The book contains a large number of text illustrations of fruits and sectional details which should prove useful for identifying the various kinds. The plates from photographs are also interesting, but they require a scale in order to make them of value for identification purposes.

BOTANY WITH AGRICULTURAL APPLICATIONS. By John C. Martin, Professor of Botany at the Iowa State College of Agriculture and Mechanic Arts. Pp. xii + 604, Med. 8vo. Second Edition. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1920.) Price 21*s*. net.

This book was reviewed in this BULLETIN (1920, **18**, 147) on the appearance—under a slightly different and less accurately descriptive title—of the first edition. The volume has been slightly enlarged, and a number of original illustrations have been inserted to replace borrowed blocks; but the new ones are little, if any, better than the old. A somewhat fuller account of the biology of the soil is given in chapter viii, and the chapters on variation, heredity and evolution have been rearranged and expanded. As a result, the importance of de Vries's work appears more emphasised, and, among minor changes in terminology, "fluctuating" is substituted for "continuous" as applied to variations, and "mode" replaces "average" in the account of biometrics. Some errors in the first edition remain uncorrected, as, for instance, the definition of free stamens as polyadelphous (p. 15) and "Albutilon" for Abutilon (p. 487); but a more serious oversight is 250° C. for — 250° C. as the temperature which seeds can resist in the resting stage, which appears on p. 68, where the explanation that the experiment was in liquid air, which would have served to suggest that the temperature was erroneous, has been deleted.

POLITICAL AND COMMERCIAL GEOLOGY AND THE WORLD'S MINERAL RESOURCES. A Series of Studies by Specialists. J. E. Spurr, Editor. Pp. ix + 562, Med. 8vo. (New York: McGraw-Hill Book Company, Inc., 1920.) Price 30*s*. net.

The editor states in the Preface that the purpose of these studies is "to shed light upon the vast importance

of commercial control of raw materials by different powers, or by the citizens of those powers, through invested capital. . . . It appeared to many of us . . . that our [i.e. the United States] Government had never grasped the vast political significance of commercial domination, and especially of the control of mineral wealth ; and that other more seasoned nations had done so, and thereby affected the interests of America and her policy very deeply, without her being aware of the circumstance." The work is divided into thirty-two chapters, written by specialists. A chapter is devoted to each of the precious and ordinary base metals ; other chapters are on the rare metals and earths of commercial importance, as radium and uranium, zirconium, monazite, thorium, and mesothorium ; on the principal earthy minerals, as emery and corundum, magnesite, graphite, mica, asbestos, and on petroleum, coal, potash and nitrogen. The general scheme adopted in the studies, with some variations in the case of certain metals or minerals, is as follows : Uses, modern changes in mining and metallurgical practice, geological distribution, geographical distribution and development, political and commercial control, position of leading commercial nations, and summary. There are numerous statistical tables, and small-scale world maps which show the distribution of deposits of petroleum, coal, manganese, chromite, vanadium, antimony, molybdenum, copper and tin, and two folding plates which show graphically political (territorial) and commercial (financial) control.

The value of the work from a statistical point of view would have been enhanced had certain of the tables been brought up to date as far as practicable, and had a few more maps been inserted showing the distribution of deposits, *e.g.* of iron, lead, zinc, tungsten, mercury, gold and silver. The work is well written, and undoubtedly supplies a want which had become intensified owing to the late war. It adds an important chapter to Mineral Economics, and will prove of special value to statesmen and governments, and at the same time should be studied by economic geologists and mining engineers—in short, by all interested in the development of the world's mineral resources.

The final chapter on "Who owns the Earth?" is by the editor, who brings out and emphasises the salient features of the studies which precede it. It is pointed out that "Japan is intently embarking on a course toward the domination of Asia, politically and commercially . . . holds to no ally that will not (temporarily) aid her in her forward march, and in the weakness of Russia,

China and Korea, she sees her opportunity. The war, to her, was an unmixed blessing. She took no chances, and seized enormous advantages," and the volume concludes with these words: "There are three great figures of nations which seem to have been destined to be, in these times, of critical importance to the United States: in the past, Germany; in the present, Great Britain; in the future, Japan. The German question was settled in the only possible way; for England the only sane solution is a closer-knit alliance; and, for Japan, watchfulness and friendly intentions."

BOOKS RECEIVED

PRODUCTS OF THE EMPIRE. By J. Clinton Cunningham, B.A. Pp. 299, Crown 8vo, with Appendix and Illustrations. (Oxford: The Clarendon Press, 1921.) Price 5*s.* 6*d.* net.

THE COCO-NUT. By E. B. Copeland. Second Edition. Pp. xvi + 225, Med. 8vo. (London: Macmillan & Co., Ltd., 1921.) Price 20*s.* net.

STUDIES IN FRENCH FORESTRY. By Theodore S. Woolsey, Jr., with two chapters by William B. Greeley. Pp. xxvi + 550, Med. 8vo. (New York: John Wiley & Sons, Inc.; London: Chapman and Hall, 1920.) Price 36*s.* net.

ECONOMIC MINERALOGY. A Practical Guide to the Study of Useful Minerals. By Thomas Crook. Pp. xi + 492, Med. 8vo. (London: Longmans, Green & Co., 1921.) Price 25*s.* net.

GEOLOGY OF THE NON-METALLIC MINERAL DEPOSITS OTHER THAN SILICATES: Vol. I—Principles of Salt Deposition. By Amadeus W. Grabau, S.M., S.D. Pp. xvi + 435, Med. 8vo. (New York and London: McGraw-Hill Book Company, Inc., 1920.) Price 30*s.* net.

GEOLOGY OF PETROLEUM. By William Harvey Emmons, Ph.D. First Edition. Pp. xiv + 610, Med. 8vo. (New York and London: McGraw-Hill Book Company, Inc., 1921.) Price 36*s.* net.

THE USE OF LOW-GRADE AND WASTE FUELS FOR POWER GENERATION. By John B. C. Kershaw, F.I.C. Pp. x + 202, Demy 8vo. (London: Constable & Co., Ltd., 1920.) Price 17*s.* net.

Recovering Precious Metals from Waste Liquid Residues. By George E. Gee. Pp. viii + 380, Demy 8vo. (London: E. & F. N. Spon, Ltd., 1920.) Price 16*s.* net.

The Chemical Analysis of Steel-works' Materials. By Fred Ibbotson, B.Sc., F.R.C.Sc.I., F.I.C. Pp. viii + 296, Demy 8vo. (London: Longmans, Green & Co., 1920.) Price 21*s.* net.

Modern Manufacture of Chemical Manures. Pp. 85, Med. 8vo. (London: Sturtevant Engineering Co., Ltd., 1920.)

Principles of Human Geography. By Ellsworth Huntington and Sumner W. Cushing. Pp. xiv + 430, Med. 8vo. (New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1921.) Price 21*s.* net.

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Botanical names and titles of books are printed in italics, and authors' names in capitals

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